PB82-107947

Areawide Stormwater Pollution Analysis with the Macroscopic Planning (ABMAC) Model. Part I Documentation and Application. Part II User's Manual

Association of Bay Area Governments
Berkeley, CA

Prepared for

Municipal Environmental Research Lab.
Cincinnati, OH

Sep 81

U.S. Department of Commerce
National Technical Information Service
NTIS

PB82-107947

BEGIN FIRST LINE OF TEXT HERE
CENTER OF PAGE
TOP OF IMAGE AREA

EPA-600/2-81-223
September 1981

DROPPED HEAD; BEGIN SECTIONS HERE

AREAWIDE STORMWATER POLLUTION ANALYSIS WITH THE MACROSCOPIC PLANNING (ABMAC) MODEL

Part I - Documentation and Application
Part II - Users Manual

by

Yoram J. Litwin
RAMLIT Associates
Hotel Claremont, Berkeley, California 94705

and

John A. Lager
William G. Smith
Metcalf & Eddy, Inc.
Palo Alto, California 94303

6-1/2"
9-1/8"

Grant No. R-806357

Project Officer

Douglas Ammon
Storm and Combined Sewer Section
Systems And Engineering Evaluation Branch
Wastewater Research Division
Municipal Environmental Research Laboratory
Cincinnati, Ohio 45268

MUNICIPAL ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES
BEGIN LAST LINE OF TEXT
EPA Form 2360-4 (4-80)
(PREVIOUSLY CIN. EPA FORM 257)
PAGE NUMBER

REPRODUCED BY
NATIONAL TECHNICAL INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

TYPING GUIDE SHEET

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/2-81-223	2. ORD Report	3. RECIPIENT'S ACCESSION NO. PB82 107947
4. TITLE AND SUBTITLE AREAWIDE STORMWATER POLLUTION ANALYSIS WITH THE MACROSCOPIC PLANNING (ABMAC) MODEL		5. REPORT DATE September 1981
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Yoram J. Litwin, John A. Lager and William G. Smith		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Association of Bay Area Governments Hotel Claremont Berkeley, California 94705		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO. R-806357
12. SPONSORING AGENCY NAME AND ADDRESS Municipal Environmental Research Laboratory - Cin., OH Office of Research and Development U.S. Environmental Protection Agency Cincinnati, OH 45268		13. TYPE OF REPORT AND PERIOD COVERED FINAL 6/78 to 11/80
		14. SPONSORING AGENCY CODE EPA/600/14
15. SUPPLEMENTARY NOTES Project Officer: Douglas C. Ammon - PHONE: 513/684-7635		

16. ABSTRACT

A simplified stormwater management model (ABMAC) has been developed to provide an inexpensive, flexible tool for areawide management of nonpoint source pollutants and for preliminary delineation of overall priorities for Best Management Practices. The model is intended for use by local engineers and planners, and is adaptable for mini-computer applications.

The model is designed to simulate runoff caused by rainfall, storage and treatment balances and to assess the magnitude of runoff and storage withdrawals. It allows for substantial flexibility in terms of input data requirements and output formats. All simulated quantities vary on a daily basis. The model can simulate nonpoint source pollution from a maximum of six land use categories. The quality constituents are biochemical oxygen demand (BOD), suspended solids (SS), volatile suspended solids (VSS), total nitrogen (TN), and total phosphorous (TP). One additional quality constituent can be user specified.

This report contains a description of the model, case study application, model calibration and testing, and the Users Manual.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Combined sewers, Drainage, Mathematical models, Overflows - sewers, Runoff, Surface water runoff, Water quality.	Combined sewer overflows, Drainage systems, Pollution abatement, Storm runoff, Urban hydrology	

18. DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE

EPA Form 2220-1 (Rev. 4-77)

187

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD. BEGIN SECTIONS HERE

DISCLAIMER

This report has been reviewed by the Municipal Environmental Research Laboratory, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

6-1/2"
9-1/8"
BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA, OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"
PAGE NUMBER
EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD, BEGIN SECTIONS HERE

FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the preservation and treatment of public drinking water supplies and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research; a most vital communications link between the researcher and the user community.

The deleterious effects of nonpoint source runoff, storm sewer discharges, and combined sewer overflows upon the nation's waterways have become of increasing concern in recent times. Efforts to alleviate the problem depend on characterization of these flows in both a quantity and quality sense.

A simplified stormwater management model, consisting of a series of interrelated tasks that combine small computer programs and hand computations, was developed and applied as an inexpensive tool for the planning and preliminary sizing of stormwater facilities (see USEPA Report EPA-600/2-76-218, August 1976). The simplified model was developed further into a macroscopic planning model and applied to (1) prioritizing implementation of best management practices for areawide management of nonpoint source runoff and (2) master planning and preliminary sizing of stormwater and combined wastewater control and treatment facilities. This report describes the development and application of the simplified macroscopic planning model for implementation of best management practices for areawide management of nonpoint source pollutants.

Francis T. Mayo
Director
Municipal Environmental Research Laboratory

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA, OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD: BEGIN SECTIONS HERE

ABSTRACT

A simplified stormwater management model (ABMAC) has been developed to provide an inexpensive, flexible tool for areawide management of nonpoint source pollutants and for preliminary delineation of overall priorities for Best Management Practices. The model is intended for use by local engineers and planners, and is adaptable for mini-computer applications.

The model is designed to simulate runoff caused by rainfall, storage, and treatment balances and to assess the magnitude of runoff and storage withdrawals. It allows for substantial flexibility in terms of input data requirements and output formats. All simulated quantities vary on a daily basis. The model can simulate nonpoint source pollution from a maximum of six land use categories. The quality constituents are biochemical oxygen demand (BOD), suspended solids (SS), volatile suspended solids (VSS), total nitrogen (TN), and total phophorous (TP). One additional quality constituent can be user specified.

This report contains a description of the model, case study application, model calibration and testing, and the Users Manual.

The report was submitted in fulfillment of Grant Number R-806357 under the sponsorship of the Environmental Protection Agency. Work was completed as of September 1980.

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

ACKNOWLEDGMENTS

Many individuals contributed directly and indirectly to the completion of this project. The authors greatfully acknowledge the assistance and coordination provided by Mr. Doug Ammon, Project Officer, and Mr. Richard Field, Chief of Storm and Combined Sewer Section, EPA Municipal Environmental Research Laboratory.

The following individuals and associated organizations were instrumental in supplying data for the various test watersheds. Their assistance is sincerely appreciated.

- Keith Carns and Carl Stinson, East Bay Municipal Utility District, Oakland, California
- George Otte, Metcalf & Eddy, Inc., Palo Alto, California
- Jack Lindley and Fred Wolin, Alameda County Flood Control and Water Conservation District, Hayward, California
- Ken Cuneo, Marin Municipal Water District, Corte Madera, California

The authors wish also to acknowledge the extensive contribution provided by Dr. E. John Finnemore and Mrs. Marianne E. Strickfaden of Metcalf and Eddy, Inc. in modification and improvement of the early version of ABMAC. In addition, Mrs. Strickfaden assisted ABAG in setting up the model on the ABAG mini-computer, performed model calibration/verification, and prepared the draft report section on the Users Manual.

Dr. Peter Russell of the Association of Bay Area Governments was the Project Manager. In addition, several ABAG staff members contributed to this project most notably Mr. Vefa Yucel and Mr. Taras Bursztynsky. Drafting and graphical expertise was provided by Mr. Ross Turner and Mr. Bruce Cates. Mrs. Yvonne McGough is given credit for her patient and conscientious typing of this report.

CONTENTS

PART I - DOCUMENTATION AND APPLICATION

Page

Figures viii
Tables. x

1. INTRODUCTION. 1

2. CONCLUSIONS 3

3. THE MACROSCOPIC PLANNING MODEL. 4

   Model Concepts 4
   System Representation 6
   Model Structure 8
   Model Operation 8
   Model Capabilities. 8
   An Example of Model Application 9

4. ANALYSIS OF CASE STUDY APPLICATION. 21

   ABAG's Surface Runoff Management Element. 21
   ABMAC Application 31

5. ABMAC MODEL REFINEMENTS 60

6. MODEL CALIBRATION AND TESTING 62

   Monitoring Stations 62
   Model Calibration 78
   Evaluation of Results 88

7. MODEL USE AND RECOMMENDATIONS 94

References. 98

PART II - USERS MANUAL

ABMAC USERS MANUAL 99

   Introduction. 99
   Model Structure and Operation 99
   ABMAC Support Program 105
   Data Requirements and Sources 110
   Initial System Setup Requirements 117
   Model Input and Output. 118
   Calibration Procedure 133
   Representative Costs and Computer Requirements. 136

PART II - USERS MANUAL

CONTENTS
(continued)

Page

References 138

APPENDIX A. LIST OF PROGRAM VARIABLES FOR ABMAC AND DATACHK PROGRAMS 139

APPENDIX B. ABMAC AND DATACHK SOURCE LISTING. 154

FIGURES

PART I

Number Page

1. Schematic Representation of ABMAC Concept 5
2. Idealized Division of Watersheds 7
3. ABMAC Model Application to the San Leandro Watershed 10
4. ABMAC Input Data Set for San Leandro Watershed 12
5. Run Results For The Upper San Leandro Watershed 14
6. Run Results For The Lower San Leandro Watershed 17
7. ABMAC Study Area 22
8. Concept of Surface Runoff Modeling 25
9. Interface of ABMAC Model with the San Francisco Bay Simulator 26
10. Capability of ABMAC/SWMM to Assess Control Measures 28
11. Area Subdivision into Modeling Units 32
12. Location of Demonstration Watersheds Selected for Site-Specific Analysis 41
13. Richmond Demonstration Watershed 42
14. Long-term Comparison of ABMAC with Measured Values 48
15. Short-term Comparison of ABMAC with Measured Values 49
16. Regional Loading Distribution - BOD 52
17. Representative Storm Impacts on Bay: BOD 54
18. Water Quality Sampling Program for ABMAC Model Calibration. 63
19. Sampling Watersheds for ABMAC Calibration 64
20. Water Quality Data for Halleck Creek 69
21. Water Quality Data for Bear Creek 72
22. Water Quality Data for Upper Matadero Creek 75

PART II

A-1 Schematic Representation of ABMAC Concept. 100
A-2 Flowchart of ABMAC MAIN Subroutine 101
A-3 Flowchart of ABMAC DAILY Subroutine. 102
A-4 Flowchart for DATACHK MAIN Subroutine. 106
A-5 Flowchart for DATACHK SPARAM Subroutine. 107
A-6 Flowchart for DATACHK SLAND Subroutine 108
A-7 Flowchart for DATACHK SQUAL Subroutine 109
A-8 Determination of Runoff Coefficient from Land Use Cover. . . 113
A-9 Imperviousness as a Function of Developed Population Density. 114
A-10 ABMAC Model Input Card Parameters Users Decision Tree. . . . 119
A-11 ABMAC Model Input. 122

FIGURES
(continued)

Number Page

A-12 Example of ABMAC Model Input Data without Default Values (NCRD = 0, NINFLG = 0, N5FLG = 0). 127
A-13 Example of ABMAC Model Input Data with Same Rainfall for all Subareas (NCRD = 0, NINFLG = 1, N5FLG = 0) . . . 128
A-14 Example of ABMAC Model Input Data with Land Use and Rainfall Consolidation Card Option (NCRD = 1, NINFLG = 1, N5FLG = 0). 129
A-15 Example of ABMAC Model Input Data for Model Run with Rainfall Data on File (NCRD = 0, NINFLG = 0, N5FLG = 1). 130
A-16 Example of ABMAC Model Input Data for Model Run with Rainfall Data on File and Land Use Consolidation Card Option (NCRD = 1, NINFLG = 0, N5FLG = 0) 131
A-17 Example of ABMAC Model Output. 132
A-18 Example of DATACHK Program Output. 134

TABLES
PART I

Number Page

1. Land Use Data For San Leandro Watershed 11
2. Effects Of Storage On Quality Of Surface Runoff 13
3. Effects Of Mitigation Measures 29
4. Summary Of SWMM Mitigation Measure Assessments 30
5. Major Watershed And Subarea Basic Data For ABMAC Analyses. 33
6. Population Projections 38
7. General Information on Demonstration Watersheds Selected for Site-Specific Analysis. 40
8. ABMAC Runoff Coefficients 39
9. Pollutant Concentrations in Stormwater Runoff 43
10. Summary of Stormwater Pollutant Concentrations 44
11. Comparison Between Uncalibrated ABMAC and Reported National Average Values by Land Use 45
12. ABAG Monitoring Test Areas. 45
13. Local Monitoring Results Grouped by Predominant Land Use. . 46
14. Comparison of ABMAC Results to Measured Values in Calabazas Watershed 47
15. Calibrated ABMAC Transferred to Berryessa Watershed 50
16. ABMAC Quality Coefficients for Regional Analysis 50
17. Sampling Sites Characteristics. 68
18. Typical Pollutant Concentrations. 79
19. Estimated Runoff Coefficient 80
20. ABMAC Verification Input Deck - First Calibration Run . . . 81
21. Matadero Creek 24-Hour Comparison - Calibration Run 1 . . . 82
22. Bear Creek 24-Hour Comparison - Calibration Run 1 83
23. Halleck Creek 24-Hour Comparison - Calibration Run 1. . . . 83
24. Seaview - Castro Valley - Calibration Run 1 84
25. Bear Creek 24-Hour Comparison - Calibration Run 2 85
26. Matadero Creek 24-Hour Comparison - Calibration Run 2 . . . 86
27. Halleck Creek 24-Hour Comparison - Calibration Run 2 . . . 86
28. Seaview - Castro Valley - Calibration Run 2 87
29. Halleck Creek 24-Hour Comparison - Calibration Run 3. . . . 88
30. Bear Creek 24-Hour Comparison - Calibration Run 3 89
31. Final Calibration Input Values 89
32. Examples of Parameter Sensitivity 91
33. Suggested Input Parameters for the Watersheds 92
34. Interfacing ABMAC with Control Measures 97

PART II

A-1 Characteristics Values for Urban Stormwater and Combined Sewer Overflow Water Quality 115
A-2 Summary of Stormwater Pollutant Concentrations. 115
A-3 Comparison of Storm Sewer Discharge Quality for Various Cities. 116
A-4 Card Input Sequence For ABMAC 124
A-5 Memory Requirements 136
A-6 Typical Costs and Execution Times 137

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD, BEGIN SECTIONS HERE

PART I. DOCUMENTATION AND APPLICATION

SECTION 1

INTRODUCTION

Section 208 of the Federal Water Pollution Control Act Amendments of 1972 established a program of planning in geographical areas with substantial water quality control problems resulting from urban-industrial concentration or other causes. Many of the areawide studies which have been initiated as a result of the 208 program placed major emphasis on nonpoint pollution problems caused by stormwater runoff. Such programs have been undertaken in just about every metropolitan area.

Evaluation of the 208 programs has revealed that identification and quantification of water quality problems caused by stormwater runoff was not as straight forward a task as one would have anticipated, considering the state of the art in this field. Some of the difficulties were related to the following:

- o in most localities the knowledge of quantity and quality of stormwater runoff was either very limited or nonexistent;
- o the schedule of the 208 studies did not provided sufficient time to develop a suitable data base;
- o definition of what constitutes a stormwater runoff problem could not always be quantitatively established - beyond the knowledge that it contains contaminants at specific concentrations;
- o The inadequate knowledge of cost and effectiveness of many non-structural measures (Best Management Practices) considered in the 208 programs, resulted in low sensitivity of the selected alternatives to the precise magnitude of the identified problem; e.g., in some instances the BMPs were selected through a virtually binary (yes/no) type of decision-making process.

These difficulties have been reflected in the diversity of approaches adopted by the various 208 agencies. In some cases simple non-analytical techniques have been seen to be most appropriate, while in other instances complex simulation procedures were adopted. It is obvious that oversimplification cannot lead to accurate results. On the other hand the overall experience with 208 programs lead many to conclude that the use of complex models does not necessarily lead to the development of a better plan. This is particularly true in instances where the decision process leading to the selection of BMPs is not as sensitive to the accuracy of input information, as was the case in analysis of point source pollution control problems.

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA, OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

The objective of this report is to document a modeling approach which while based on simple concepts, is adequate for the level of sophistication required by many areawide planning activities. The presented model establishes a balance between the extremes of large and complex models on one hand and over simplification of certain, virtually nonanalytical, approaches on the other. This approach is formulated as a Macroscopic Planning Model or MAC. It has been used during 1976-1978 by the Association of Bay Area Governments (ABAG) to prepare an Environmental Management Plan (EMP) for the San Francisco Bay Area under Section 208 of the Federal Water Pollution Control Act Amendments of 1972. Subsequently, the model has been refined to provide certain user oriented conveniences that were missing in the earlier version of the model and were subsequently detected in ABAG's application. The refined model is now referred to as ABMAC and is available for application in the continuing planning process by local planning agencies.

CONCLUSIONS

1. ABMAC Model represents a useful tool for estimating and projecting pollutant loadings under varying growth plans and mitigation strategies. Model application and testing in the San Francisco Bay Area during 1976-78, and additional testing during 1978-80 in four undeveloped watersheds, indicated satisfactory agreement between recorded and simulated records.

2. The model is now available for use. The main benefactors should be local planning agencies who can apply the model in their continuous evaluation of the impacts of land use policies on the generation of nonpoint source pollutants.

3. The model simulates runoff and pollutant washoff from different land use areas on a daily basis. Up to six land use categories and up to six quality constituents can be simulated.

4. The model allows for considerable flexibility in terms of input data requirements and output formats. It is also flexible in terms of computer system applications. It has been tested on a Sperry Univac V76 Mini Computer and an IBM Model 3033.

5. The model offers the option to test all input data for reliability and consistency. This is an important feature in large model applications where preparation of input data is very tedious and prone to mistakes.

6. The model can be effectively used in conjunction with more sophisticated models of stormwater runoff and receiving waters. In such applications ABMAC looks at broad areas and long periods of record, while the more sophisticated models can be both site and storm specific, and can be best applied to selected, relatively small watersheds.

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD, BEGIN SECTIONS HERE

SECTION 3

THE MACROSCOPIC PLANNING MODEL

ABMAC is a special purpose, continuous simulation model employing simplified techniques for representing prototype behavior. The input data requirements are minimal; the areal and temporal coverage is broad; and the model is both flexible and easily applied. The model was specifically developed to provide a relatively inexpensive, reasonably accurate, and flexible tool for 208 planning and preliminary sizing of stormwater facilities. Its acronym stems from Association of Bay Area Governments (ABAG) Macroscopic Planning Model (MAC), which was the initial model application by a 208 planning agency [2].

MODEL CONCEPTS

6-1/2"

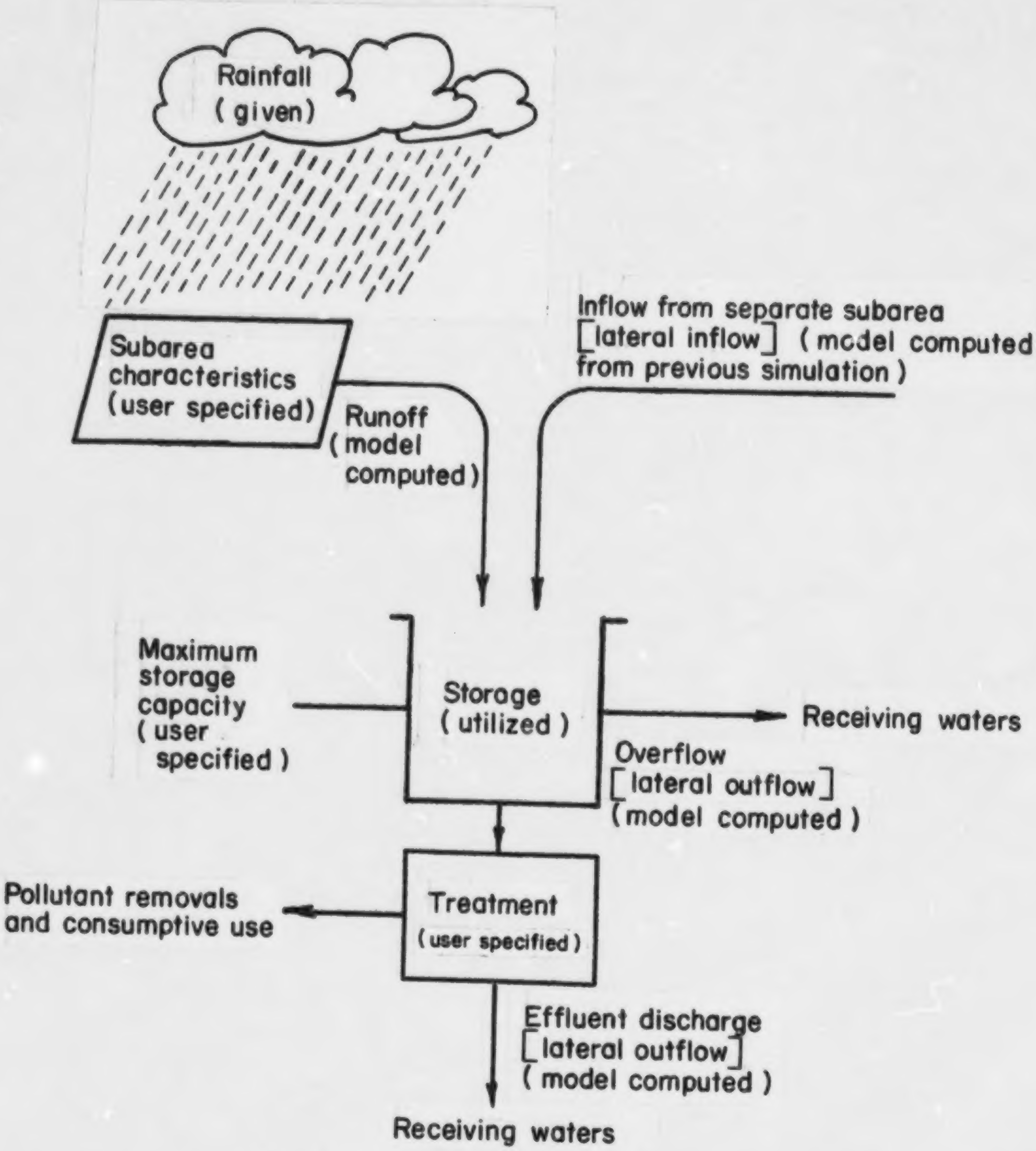
The model has as its foundation the so-called "rational method" which relates runoff rate to drainage area, intensity of rainfall and perviousness of the surface. It is an established tool for the analysis of runoff. This simple equation, which states the rainfall-runoff relationship is the basis for the ABMAC model. It is coupled with load computations for several constituents and analyses of multiple land uses. Continuous calculations for short time intervals provide simulation results which are useful for establishing size-effectiveness relationships. The fact that such relationships are easily understandable by all participants may lead, in some cases, to the simplification of decision making process in the areawide planning activities.

A conceptual representation of the ABMAC model operation is shown in Figure 1. Rainfall is the driving variable of the the model. It is converted into runoff and an ultimate discharge to receiving waters through a storage-treatment balance. This conversion is based on the gross runoff coefficient (K-factor) and quality coefficients associated with various water quality parameters. The resulting runoff is stored in a specific storage volume, characterized by an assigned treatment rate. Conceptually such storage might be zero and/or no treatment may be specified. If a treatment is specified in ABMAC Model inputs, it models an actual treatment facility or an interceptor capacity and effectiveness. When the runoff volume exceeds the specified storage capacity and its treatment rate, an overflow or discharge to receiving waters occurs.

This is a simple concept. The benefits of its computer representation are manifested when a number of watersheds with different growth characteristics, land use, and management practices are being evaluated for a long sequence of rainfall data. This is demonstrated in Section 4 where a case study is discussed.

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)


Rainfall
(given)
Subarea
characteristics
(user specified)
Runoff
(model
computed)
Inflow from separate subarea
[lateral inflow] (model computed
from previous simulation)
Maximum
storage
capacity
(user
specified)
Storage
(utilized)
Receiving waters
Overflow
[lateral outflow]
(model computed)
Pollutant removals
and consumptive use
Treatment
(user specified)
Effluent discharge
[lateral outflow]
(model computed)
Receiving waters

Note : Simulation repeated for each subarea (computational unit)

SCHEMATIC REPRESENTATION OF ABMAC CONCEPT

Figure 1

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

SYSTEM REPRESENTATION

The ABMAC Model allows representation of the study area through a three level division into functional, hydrological and land use entitles. At first the entire study area is broken into functional political or demographic units because results for such units are most usable. The second division is into major watersheds based on the hydrographic boundaries of these areas. The third division is into subareas. Subareas are the actual units for which model computations are carried out. These units provide some geographical area that can be focused on as a potential pollution source. The subareas do not necessarily conform to hydrographic boundaries and sometimes they may not even be contiguous. These areas are selected to reflect general land use and development patterns. Idealistically, the first and usually geographically highest area is labeled natural or protected; the second area is the open and agricultural land that is labeled as potentially developable, and the third area is the currently developed area which is labeled as existing urban. These subareas are respectively designated as A, B and C in Figure 2.

In the model each subarea is characterized by five terms as follows:

(1) Area of land in acres for the different land uses within the subarea (residential, commercial, industrial, etc.) It is very important that the land use classification be broad enough to include all of the land in a particular subarea.

(2) Gross runoff coefficient, or the "K" factor which reflects the average annual runoff divided by the average annual rainfall. Computationally this term is similar to "C" in the rational method.

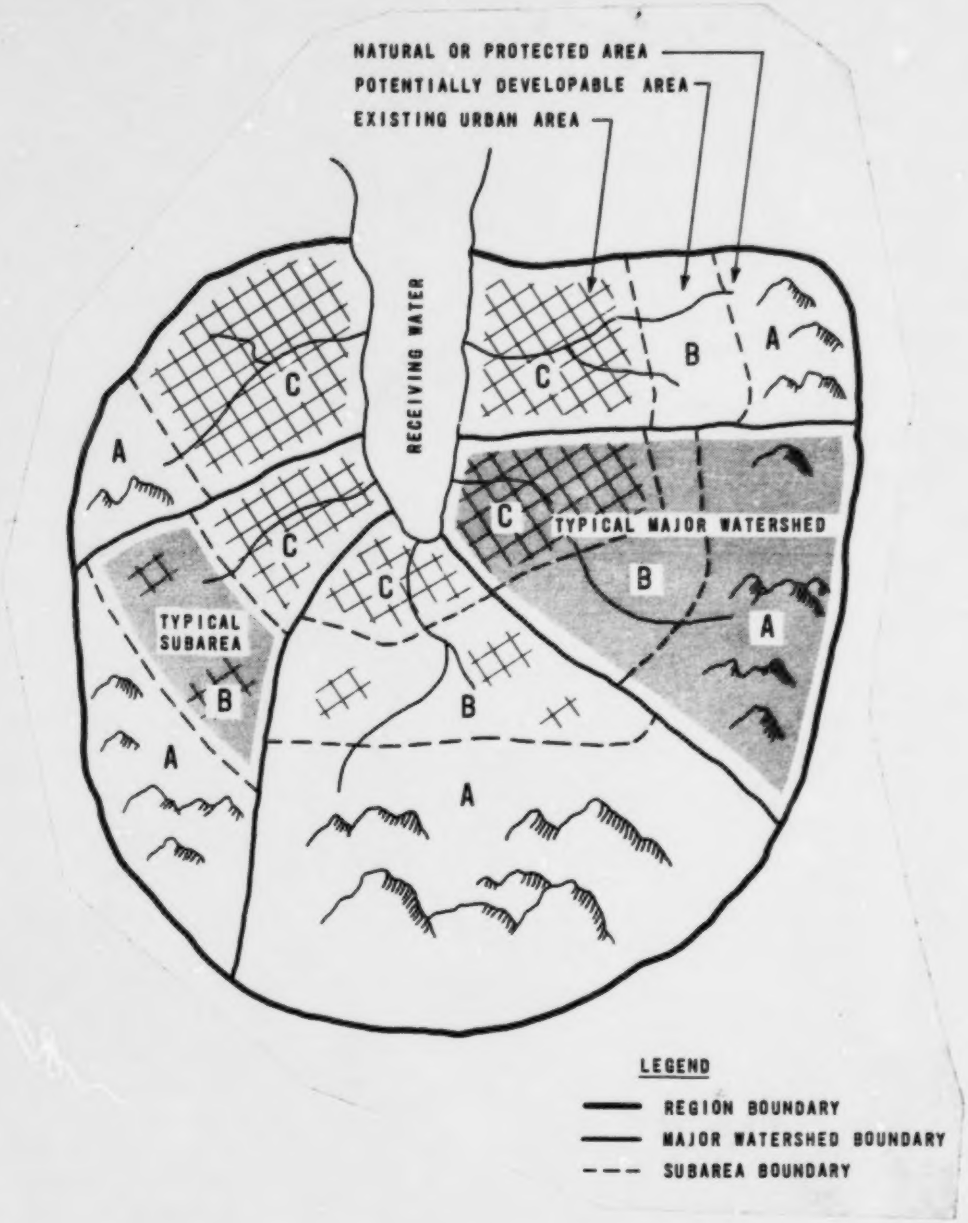
(3) Pollutant concentrations in surface runoff. This information is provided in mg/l for each land use specified for a given subarea. It is based on local data if available. Otherwise regional or national data may be used. Since precisely uniform land use conditions do not exist, such data must be used with caution. Usually they are only sufficiently accurate for indicating trends and order of magnitude comparisons of urban land uses. Typical concentrations are provided in Tables A-1 through A-3 in Part II.

(4) Storage - Treatment relationships of existing or proposed mitigation measures, reservoirs and treatment facilities within the subarea.

(5) A rainfall factor which is used to transpose rainfall from the primary gages for which long-term rainfall data are available to the subarea being analyzed.

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"
PAGE NUMBER

EPA-287 (Cin.)
(4-76)


NATURAL OR PROTECTED AREA
POTENTIALLY DEVELOPABLE AREA
EXISTING URBAN AREA
RECEIVING WATER
A
B
C
TYPICAL MAJOR WATERSHED
TYPICAL SUBAREA
LEGEND
REGION BOUNDARY
MAJOR WATERSHED BOUNDARY
SUBAREA BOUNDARY

IDEALIZED DIVISION OF WATERSHEDS

Figure 2

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD. BEGIN SECTIONS HERE

MODEL STRUCTURE

The model is composed of three primary elements as follows:

1. The executive, or MAIN Program, which reads-in the input data, sets the operation modes, quality options, printing options, etc.

2. The DAILY Subroutine which preforms the daily simulation, initializes subarea variables; computes runoff, storage, overflow, and other variables; and prints the different outputs as required.

3. Input data checking program, DATACHK, which reads-in and initially checks all the data. All variables are then assigned to one of three subroutines for printing and statistical checks.

The detailed description of model structure is provided in Part II - Users Manual.

MODEL OPERATION

9-1/8"

Given a rainfall history, ABMAC computes runoff from differing land use areas and combines these with a known lateral inflow into storage. ABMAC can next compute treated withdrawals from storage, if desired, and then determine resulting storage volume and overflows, if any. All computations are repeated on a daily basis. The program prints out the status of all variables on either a daily, monthly, yearly or subareal basis depending on user preference. Also included are summaries for each water year, subarea and total run. ABMAC can repeat the above process for many subareas within the same run. In addition, the daily withdrawals and/or overflows may be written on disk files for future use as input (lateral inflows) to down-stream segments.

Simplified flow charts of the ABMAC MAIN program segment and DAILY subroutine are provided in Figures A-2 and A-3 in Part II, which also provides a more detailed explanation of specific model features.

MODEL CAPABILITIES

The model simulates nonpoint pollutants from a maximum of six land uses in a single simulation run. The water quality constituents simulated include biochemical oxygen demand, suspended solids, volatile suspended solids, total nitrogen and total phosphorus. One additional constituent can be user specified. All are considered to be conservative.

BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
BEGIN LAST LINE OF TEXT
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD: BEGIN SECTIONS HERE

The model provides flexible input/output options (input can be read from file, disk, or from cards). Several printing options are also available. They enable the user to shape the output to the specific level of detail required and to generate output which provides (1) summaries of input data, (2) the simulated variables values, and (3) a run summary.

The associated data checking program was specifically developed to process run input data without initiating the MAIN Model algorithm. Due to minicomputer size limitations this pre-processor had to be a seperate program, operated in conjunction with ABMAC. The program provides some error checking and tabulation of input data by subareas to allow the user to easily scan data for inconsistencies.

The Users Manual, Part II, contains a full description of the ABMAC Model capabilities.

6-1/2"

AN EXAMPLE OF MODEL APPLICATION

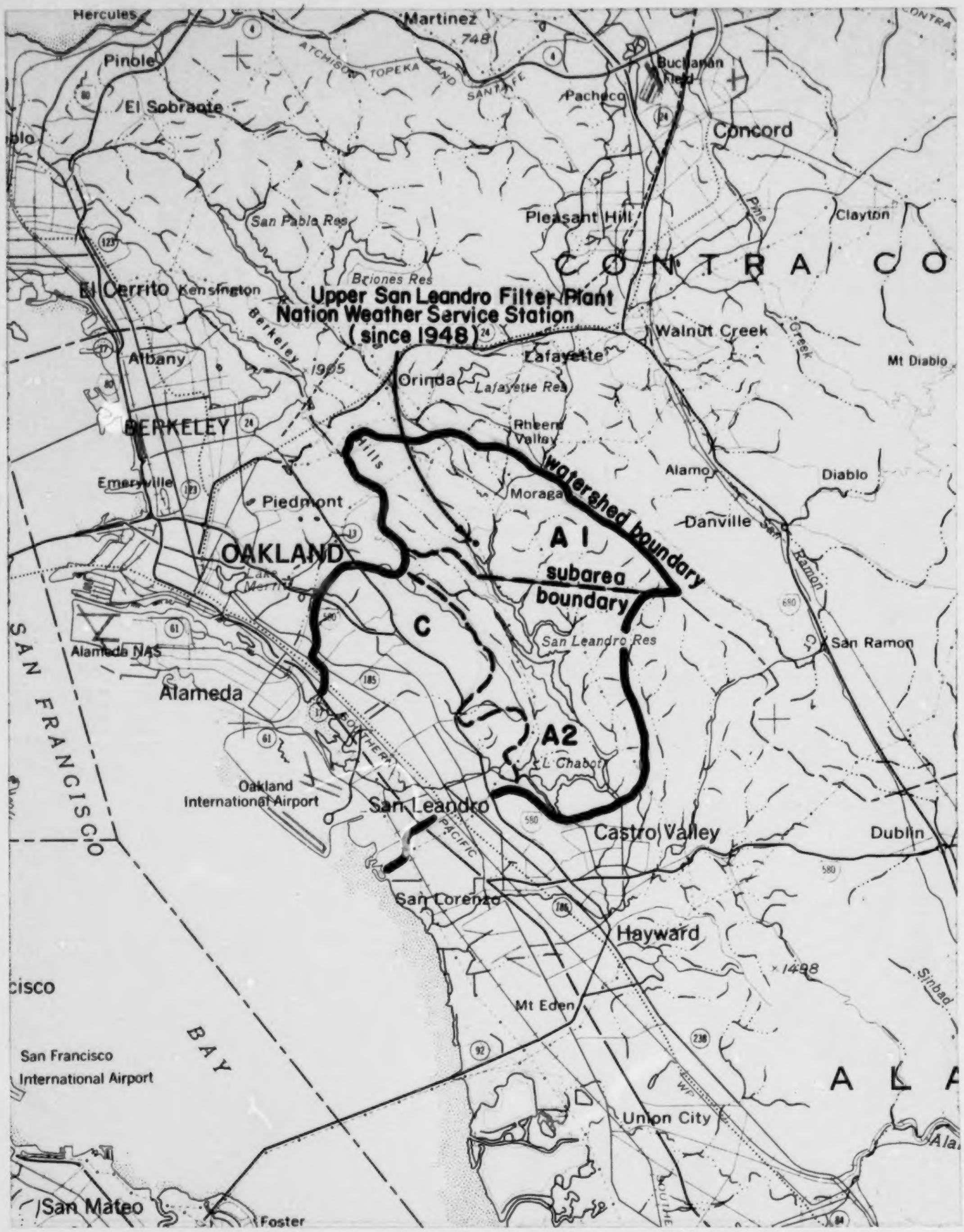
The San Leandro Watershed in the San Francisco Bay Area was selected to serve as an example for ABMAC application (see Figure 3). The purpose of this example is to demonstrate model applicability to areawide water quality planning. The total drainage area of this watershed is 76 square miles. It includes both the developed and undeveloped areas. It also covers two jurisdictional units of government, 34 percent of the drainage area is located in Contra Costa County, while the remaining portion is in Alameda County. This is a typical problem for areawide water quality planning by local governments where results and decisions are usually made by jurisdictional rather than hydrographic units.

ABMAC application to this watershed consisted of the following steps:

- o definition of watershed boundaries and subdivision into subareas;
- o selection of gross runoff coefficients and pollutant concentrations for each subarea;
- o selection of rainfall data and rainfall factor for each subarea;
- o preparation of remaining model input data (run options, storage information, etc.) and model execution (see Part II - Users Manual).

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)


Upper San Leandro Filter Plant
Nation Weather Service Station
(since 1948)
watershed boundary
subarea boundary
A1
A2
C
Hercules
Martinez
Pinole
El Sobrante
Pacheco
Buchanan Field
Concord
San Pablo Res
Pleasant Hill
Clayton
CONTRA CO
Briones Res
El Cerrito
Kensington
Walnut Creek
Albany
Orinda
Lafayette
Lafayette Res
Mt Diablo
BERKELEY
Rheem Valley
Alamo
Diablo
Emeryville
Piedmont
Moraga
Danville
OAKLAND
Lake Merritt
San Leandro Res
San Ramon
Alameda NAS
Alameda
SAN FRANCISCO
L Chabot
Oakland International Airport
San Leandro
Castro Valley
Dublin
San Lorenzo
Hayward
Mt Eden
BAY
San Francisco International Airport
ALA
Union City
San Mateo
Foster

ABMAC MODEL APPLICATION TO THE SAN LEANDRO WATERSHED

Figure 3

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

For the San Leandro Watershed the subdivision into subareas is shown in Figure 3. Table 1 shows the breakdown by land use. The information on land use within each subarea was obtained from individual county records. This division was made to accommodate the following:

- interface with census tracks and population projection zones;
- evaluation of alternative future development patterns;
- assessment of different control practices and their relative impact in the two counties and for the different land uses.

TABLE 1. LAND USE DATA FOR SAN LEANDRO WATERSHED (in acres)

Land Use	Subarea A1	Subarea A2	Subarea C	Total
Residential	1,475	295	8,451	10,221
Commercial	655	42	1,803	2,500
Industrial	18	11	2,638	2,667
Open	14,587	11,591	7,137	33,315
TOTAL	16,735	11,939	20,029	48,703

The gross runoff coefficients and pollutant concentrations were derived from a local data collection program modified when necessary by national data. These are shown in Figure 4.

Rainfall data were obtained from the National Weather Service for the upper San Leandro Station. Data for this station are available since 1948. In this example only 2 years of data were used. The rainfall data were adjusted for each subarea using the following rainfall factors:

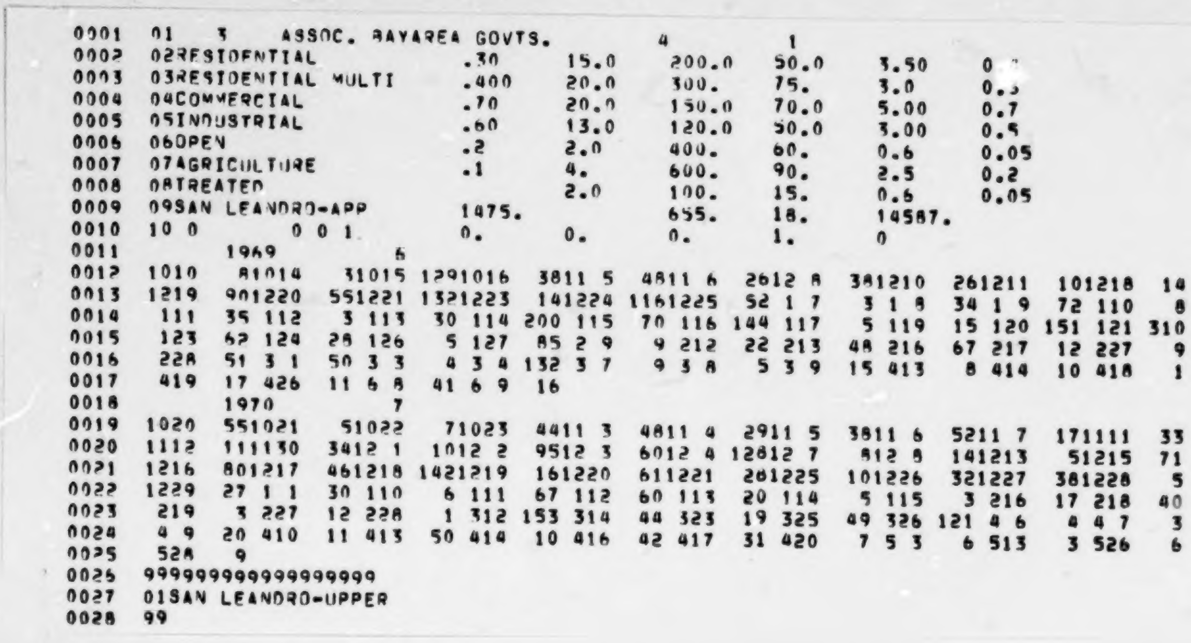
Subarea A1	1.0
Subarea A2	1.2
Subarea C	0.7

If more than one rainfall station is available one of the standard procedures (such as the Thiessen-weighted average, isohyetal average or arithmetic average) can be applied to obtain a representative rainfall data set for the study area.

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

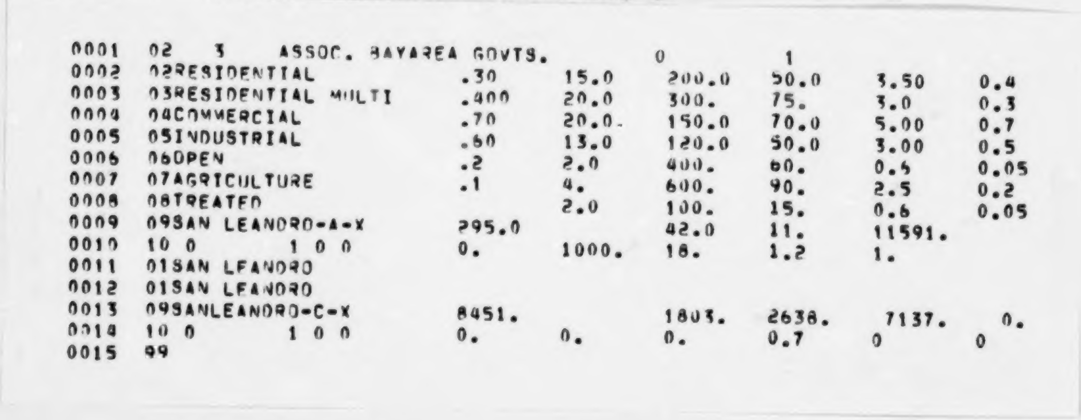
EPA-287 (Cin.)
(4-76)

Step I   Data set for Subarea A I



```
0001  01   3    ASSOC. BAYAREA GOVTS.              4         1
0002  02RESIDENTIAL                  .30      15.0     200.0     50.0      3.50     0.[illegible]
0003  03RESIDENTIAL MULTI            .400     20.0     300.      75.       3.0      0.3
0004  04COMMERCIAL                   .70      20.0     150.0     70.0      5.00     0.7
0005  05INDUSTRIAL                   .60      13.0     120.0     50.0      3.00     0.5
0006  06OPEN                         .2       2.0      400.      60.       0.6      0.05
0007  07AGRICULTURE                  .1       4.       600.      90.       2.5      0.2
0008  08TREATED                               2.0      100.      15.       0.6      0.05
0009  09SAN LEANDRO-APP              1475.             655.      18.       14587.
0010  10 0          0 0 1            0.       0.       0.        1.        0
0011        1969          6
0012  1010    81014    31015 1291016   3811 5   4811 6   2612 8   381210   261211   101218   14
0013  1219  901220   551221 1321223   141224 1161225   52 1 7    3 1 8   34 1 9   72 110    8
0014   111  35 112    3 113  30 114 200 115  70 116 144 117    5 119   15 120  151 121  310
0015   123  62 124   28 126   5 127   85 2 9    9 212   22 213   48 216   67 217   12 227    9
0016   228  51 3 1   50 3 3   4 3 4  132 3 7    9 3 8    5 3 9   15 413    8 414   10 418    1
0017   419  17 426   11 6 8  41 6 9   16
0018        1970          7
0019  1020  551021    51022   71023   4411 3   4811 4   2911 5   3811 6   5211 7   171111   33
0020  1112  111130   3412 1  1012 2   9512 3   6012 4  12812 7    812 8   141213    51215   71
0021  1216  801217   461218 1421219   161220   611221   281225   101226   321227   381228    5
0022  1229  27 1 1   30 110   6 111   67 112   60 113   20 114    5 115    3 216   17 218   40
0023   219   3 227   12 228   1 312  153 314   44 323   19 325   49 326  121 4 6    4 4 7    3
0024   4 9  20 410   11 413  50 414   10 416   42 417   31 420    7 5 3    6 513    3 526    6
0025   528   9
0026  99999999999999999
0027  01SAN LEANDRO-UPPER
0028  99
```

Step 2   Data set for Subareas A2 and C



```
0001  02   3    ASSOC. BAYAREA GOVTS.              0         1
0002  02RESIDENTIAL                  .30      15.0     200.0     50.0      3.50     0.4
0003  03RESIDENTIAL MULTI            .400     20.0     300.      75.       3.0      0.3
0004  04COMMERCIAL                   .70      20.0     150.0     70.0      5.00     0.7
0005  05INDUSTRIAL                   .60      13.0     120.0     50.0      3.00     0.5
0006  06OPEN                         .2       2.0      400.      60.       0.6      0.05
0007  07AGRICULTURE                  .1       4.       600.      90.       2.5      0.2
0008  08TREATED                               2.0      100.      15.       0.6      0.05
0009  09SAN LEANDRO-A-X              295.0             42.0      11.       11591.
0010  10 0          1 0 0            0.       1000.    18.       1.2       1.
0011  01SAN LEANDRO
0012  01SAN LEANDRO
0013  09SANLEANDRO-C-X               8451.             1803.     2638.     7137.      0.
0014  10 0          1 0 0            0.       0.       0.        0.7       0          0
0015  99
```

ABMAC INPUT DATA SET
FOR SAN LEANDRO WATERSHED

Figure 4

TYPING GUIDE SHEET

Model execution was made in two steps.(1) The first data set (see Figure 4) was prepared for subarea A1, which represents the undeveloped areas located in Contra Costa County. Separate results for this subarea were of interest because it is located in a different jurisdictional unit. In this case, the NSUBS parameter (number of subareas) was set equal to 1. Since the rainfall data were provided as input, the N5FLG parameter was set to 1. No treatment was specified in this run because the purpose was to obtain baseline data. The results are shown in Figure 5. Since there was no treatment, all runoff is shown as overflow with specific quality characteristics presented in thousands of pounds for each of the five specified pollutants.

In the second step the model was executed for the two subareas located in Alameda County. A2, the first subarea, represents the undeveloped portion of the watershed, while C, the second subarea, represents the urban development within this watershed. In this case, the results from the first run for subarea A1 were used as lateral inflow to subarea A2. The N1FLG for lateral inflows was therefore set as 1. Since the rainfall data were already provided there was no need to include them in the input string. The N5FLG was set to 0. The pollutant concentration and gross runoff coefficients were similar for most land uses in these two subareas. To demonstrate some of the model capabilities, the card consolidation option was used here. As shown in Figure 4 with this option in effect (NCRD = 1), data for subarea A2 were specified and then additional information was entered for subarea C only if it differed from subarea A2. As discussed in Section 4, this option is of significant value if a large number of watersheds and subareas are analyzed.

Another important feature of this example run is the use of storage. The San Leandro Reservoir, located in subarea A2, collects all runoff (up to a specified maximum storage volume), which is released at a specified withdrawal rate. ABMAC allows specification of the treatment rates. Table 2 shows the treatment rates used in this example.

TABLE 2. EFFECTS OF STORAGE ON QUALITY OF SURFACE RUNOFF

Pollutant	Pollutant Concentration (mg/l) Pre-storage range	 After-storage
BOD	2 - 20	2
SS	120 - 600	100
VSS	50 - 90	15
TOT-N	0.6 - 5.0	0.6
TOT-P	0.05 - 0.7	0.05

---

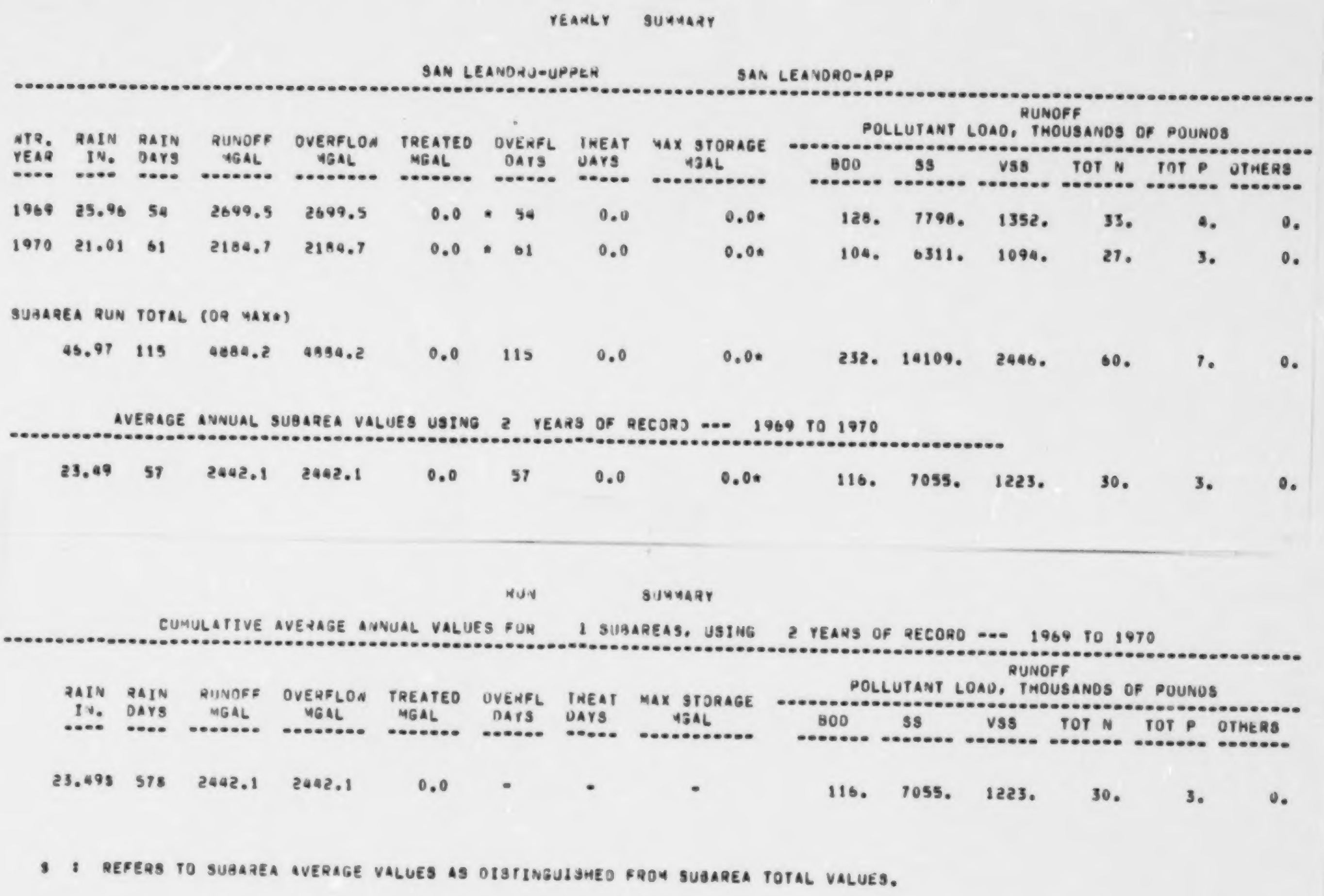
(1) The reader cannot fully benefit from the following discussion until becoming acquainted with information provided in the Users Manual in Part II of this report.

BEGIN FIRST LINE OF TEXT HERE
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE
BEGIN LAST LINE OF TEXT
3/8"
PAGE NUMBER
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
EPA-287 (Cin.)
(4-76)

```
                                                  ASSOC. BAYAREA GOVTS        METCALF & EDDY, INC., ENGINEERS
                                                  --------------------        1029 CORPORATION WAY
                                                  --------------------        P.O. BOX 10-046
                                                                              PALO ALTO, CALIF. 94303


                        SAN LEANDRO-UPPER               SAN LEANDRO-APP
--------------------------------------------------------------------------------------------------
                                                   POLLUTANT CONCENTRATION IN SURFACE RUNOFF, MG/L
                               AREA                -----------------------------------------------
       LAND USE                ACRES    K-FACTOR    BOD      SS       VSS      TOT N    TOT P    OTHERS
--------------------          -------   --------  -------  -------  -------  -------  -------  -------

RESIDENTIAL                    1475.      .30      15.00   200.00    50.00     3.50      .40     0.00
RESIDENTIAL MULTI                 0.      .40      20.00   300.00    75.00     3.00      .30     0.00
COMMERCIAL                      655.      .70      20.00   150.00    70.00     5.00      .70     0.00
INDUSTRIAL                       18.      .60      13.00   120.00    50.00     3.00      .50     0.00
OPEN                          14587.      .20       2.00   400.00    60.00      .60      .05     0.00
AGRICULTURE                       0.      .10       4.00   600.00    90.00     2.50      .20     0.00

-------------------------------------------
QUALITY OF WITHDRAWAL FROM STORAGE:
TREATED                                             2.00   100.00    15.00      .60      .05     0.00

TOTAL AREA   K-FACTOR        MAX STORAGE      WITHDRAWAL RATE   RAINFALL            QUALITY
  ACRES      OVERRIDE           MGAL              MGAL/D         FACTOR              OPTION
----------   --------      ---------------   ---------------   --------   -------------------------
  16735.        0.00             0.0                 0.0           1.00     0          RUNOFF
```

RUN RESULTS FOR THE
UPPER SAN LEANDRO WATESHED

Figure 5



```
                                                YEARLY   SUMMARY

                                   SAN LEANDRO-UPPER          SAN LEANDRO-APP
--------------------------------------------------------------------------------------------------------------------------------
                                                                                                    RUNOFF
WTR.  RAIN  RAIN    RUNOFF   OVERFLOW   TREATED   OVERFL   TREAT   MAX STORAGE        POLLUTANT LOAD, THOUSANDS OF POUNDS
YEAR   IN.  DAYS     MGAL      MGAL       MGAL     DAYS    DAYS       MGAL      ------------------------------------------------
----  ----  ----   -------   --------   -------   ------   -----   -----------     BOD      SS      VSS    TOT N   TOT P  OTHERS
                                                                                 ------- ------- ------- ------- ------- -------

1969  25.96  54    2699.5    2699.5       0.0  *  54       0.0          0.0*      128.   7798.   1352.     33.      4.      0.
1970  21.01  61    2184.7    2184.7       0.0  *  61       0.0          0.0*      104.   6311.   1094.     27.      3.      0.

SUBAREA RUN TOTAL (OR MAX*)

     45.97 115     4884.2    4884.2       0.0    115       0.0          0.0*      232.  14109.   2446.     60.      7.      0.

         AVERAGE ANNUAL SUBAREA VALUES USING  2  YEARS OF RECORD ---  1969 TO 1970
----------------------------------------------------------------------------------------------------

     23.49   57    2442.1    2442.1       0.0     57       0.0          0.0*      116.   7055.   1223.     30.      3.      0.


                                                RUN          SUMMARY

                 CUMULATIVE AVERAGE ANNUAL VALUES FOR    1 SUBAREAS, USING   2 YEARS OF RECORD ---  1969 TO 1970
--------------------------------------------------------------------------------------------------------------------------------
                                                                                                    RUNOFF
      RAIN  RAIN   RUNOFF   OVERFLOW   TREATED   OVERFL   TREAT   MAX STORAGE        POLLUTANT LOAD, THOUSANDS OF POUNDS
       IN.  DAYS    MGAL      MGAL       MGAL     DAYS    DAYS       MGAL      ------------------------------------------------
      ----  ----  -------   --------   -------   ------   -----   -----------     BOD      SS      VSS    TOT N   TOT P  OTHERS
                                                                                ------- ------- ------- ------- ------- -------

    23.49$  57$    2442.1    2442.1       0.0      -        -          -           116.   7055.   1223.     30.      3.      0.

    $ : REFERS TO SUBAREA AVERAGE VALUES AS DISTINGUISHED FROM SUBAREA TOTAL VALUES.
```

RUN RESULTS FOR THE
UPPER SAN LEANDRO WATESHED
Figure 5 (concl.)

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

It must be emphasized that the inflow to the storage includes runoff from both subareas A1 and A2. Similarly, the final results, shown in Figure 6, combine flow and pollutant loads for all three subareas. The main value of the obtained pollutant loads is not in their absolute values however, but in their ability to establish the relative magnitude of contributions from different areas, as well as the potential impacts on these relative values due to: (1) future development, and (2) quality effects of instituting various mitigation measures within the analyzed subareas.

6-1/2"
9-1/8"
BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

I. Run results for Subarea A 2

```
                                                ASSOC. BAYAREA GOVTS          METCALF & EDDY, INC., ENGINEERS
                                                --------------------          1029 CORPORATION WAY
                                                --------------------          P.O. BOX 10-046
                                                                              PALO ALTO, CALIF. 94303


                         SAN LEANDRO                          SAN LEANDRO-A-X
-----------------------------------------------------------------------------------------------------------
                                                PULLUTANT CONCENTRATION IN SURFACE RUNOFF, MG/L
                            AREA                ---------------------------------------------------------
     LAND USE               ACRES    K-FACTOR    BOD       SS        VSS      TOT N     TOT P     OTHERS
--------------------       -------   --------   -------   -------   -------   -------   -------   -------
                                                                                                      *
RESIDENTIAL                  295.       .30      15.00    200.00     50.00      3.50       .40      0.00
RESIDENTIAL MULTI              0.       .40      20.00    300.00     75.00      3.00       .30      0.00
COMMERCIAL                    42.       .70      20.00    150.00     70.00      5.00       .70      0.00
INDUSTRIAL                    11.       .60      13.00    120.00     50.00      3.00       .50      0.00
OPEN                       11591.       .20       2.00    400.00     60.00       .60       .05      0.00
AGRICULTURE                    0.       .10       4.00    600.00     90.00      2.50       .20      0.00

---------------------------------------------
QUALITY OF WITHDRAWAL FROM STORAGE:
TREATED                                           2.00    100.00     15.00       .60       .05      0.00

TOTAL AREA  K-FACTOR        MAX STORAGE      WITHDRAWAL RATE  RAINFALL              QUALITY
  ACRES     OVERRIDE           MGAL              MGAL/D         FACTOR               OPTION
----------  --------     ---------------    ---------------   --------      -----------------------
  11939.       0.00          1000.0                   18.0        1.20      1          OVERFLOW
```

RUN RESULTS FOR THE
LOWER SAN LEANDRO WATERSHED

Figure 6

```
                                             YEARLY   SUMMARY

                                  SAN LEANDRO                    SAN LEANDRO-A-X
------------------------------------------------------------------------------------------------------------------
                                                                                         OVERFLOW
                                                                          POLLUTANT LOAD, THOUSANDS OF POUNDS
WTR.  RAIN  RAIN   RUNOFF  OVERFLOW  TREATED  OVERFL  TREAT  MAX STORAGE  ---------------------------------------------------
YEAR  IN.   DAYS   MGAL     MGAL     MGAL     DAYS    DAYS     MGAL          BOD      SS      VSS    TOT N   TOT P  OTHERS
----  ----  ----  -------  --------  -------  ------  -----  -----------   ------- ------- ------- ------- ------- -------

1969  31.15  58    2066.4     0.0    2066.4 *    0    114.8       688.3*       0.       0.      0.      0.      0.      0.

1970  25.21  61    1672.4     0.0    1672.4 *    0     92.9.      280.2*       0.       0.      0.      0.      0.      0.


SUBAREA RUN TOTAL (OR MAX*)

      56.36  119   3738.8     0.0    3738.8      0    207.7       688.3*       0.       0.      0.      0.      0.      0.


         AVERAGE ANNUAL SUBAREA VALUES USING  2  YEARS OF RECORD ---  1969 TO 1970
---------------------------------------------------------------------------------------------

      28.18   57   1869.4     0.0    1869.4      0    103.9       688.3*       0.       0.      0.      0.      0.      0.
```

RUN RESULTS FOR THE
LOWER SAN LEANDRO WATERSHED

Figure 6 (cont.)

2. Run results for Subarea C

```
                    SAN LEANDRO                         , SANLEANDRO-C-X
-------------------------------------------------------------------------------------------------------
                                                 POLLUTANT CONCENTRATION IN SURFACE RUNOFF, MG/L
                           AREA                  ------------------------------------------------------
      LAND USE             ACRES    K-FACTOR     BOD       SS       VSS      TOT N     TOT P    OTHERS
-------------------       -------   --------   -------  -------   -------   -------   -------  -------

RESIDENTIAL                8451.       .30      15.00   200.00     50.00      3.50       .40     0.00
RESIDENTIAL MULTI             0.       .40      20.00   300.00     75.00      3.00       .30     0.00
COMMERCIAL                 1803.       .70      20.00   150.00     70.00      5.00       .70     0.00
INDUSTRIAL                 2638.       .60      13.00   120.00     50.00      3.00       .50     0.00
OPEN                       7137.       .20       2.00   400.00     60.00       .60       .05     0.00
AGRICULTURE                   0.       .10       4.00   600.00     90.00      2.50       .20     0.00

-----------------------------------------
QUALITY OF WITHDRAWAL FROM STORAGE:
TREATED                                          2.00   100.00     15.00       .60       .05     0.00

TOTAL AREA  K-FACTOR        MAX STORAGE      WITHDRAWAL RATE  RAINFALL          QUALITY
   ACRES    OVERRIDE           MGAL              MGAL/D        FACTOR            OPTION
----------  --------     ---------------    ---------------   --------   -----------------------
  20029.       0.00             0.0                 0.0           .70     0        RUNOFF

                                 YEARLY   SUMMARY


                           SAN LEANDRO                     SANLEANDRO-C-X
---------------------------------------------------------------------------------------------------------------------
                                                                                         RUNOFF
                                                                             POLLUTANT LOAD, THOUSANDS OF POUNDS
WTR.  RAIN  RAIN   RUNOFF  OVERFLOW  TREATED  OVERFL  THEAT  MAX STORAGE  ---------------------------------------------
YEAR   IN.  DAYS    MGAL     MGAL      MGAL    DAYS   DAYS      MGAL        BOD     SS      VSS    TOT N   TOT P  OTHERS
----  ----  ----  -------  --------  -------  ------  -----  -----------  ------- ------- ------- ------- ------- -------

1969  18.17  54    3359.4   3359.4     0.0 *  54       0.0          0.0*      357.   6001.   1564.     86.     11.     0.

1970  14.71  61    2718.8   2718.8     0.0 *  61       0.0          0.0*      289.   4857.   1266.     69.      9.     0.


SUBAREA RUN TOTAL (OR MAX*)

     32.88  115    6078.2   6078.2     0.0   115       0.0          0.0*      646.  10858.   2831.    155.     21.     0.


         AVERAGE ANNUAL SUBAREA VALUES USING  2  YEARS OF RECORD ---  1969 TO 1970
-----------------------------------------------------------------------------------------

     16.44   57    3039.1   3039.1     0.0    57       0.0          0.0*      323.   5429.   1415.     77.     10.     0.
```

RUN RESULTS FOR THE LOWER SAN LEANDRO WATERSHED

Figure 6 (cont.)

3. Combined run results for Subareas A1, A2 and C

```
                                        RUN          SUMMARY

              CUMULATIVE AVERAGE ANNUAL VALUES FOR    2 SUBAREAS, USING   2 YEARS OF RECORD ---  1969 TO 1970
-------------------------------------------------------------------------------------------------------------------
                                                                                          RUNOFF
                                                                         POLLUTANT LOAD, THOUSANDS OF POUNDS
 RAIN  RAIN   RUNOFF  OVERFLOW  TREATED  OVERFL  TREAT  MAX STORAGE  -----------------------------------------------
  IN.  DAYS    MGAL     MGAL      MGAL    DAYS   DAYS      MGAL         BOD     SS      VSS    TOT N   TOT P  OTHERS
 ----  ----  -------  --------  -------  ------  -----  -----------   ------- ------- ------- ------- ------- -------

22.31$  57$   4908.5   3039.1    1869.4     -      -         -          323.   5429.   1415.    77.     10.      0.

$ : REFERS TO SUBAREA AVERAGE VALUES AS DISTINGUISHED FROM SUBAREA TOTAL VALUES.
```

RUN RESULTS FOR THE LOWER SAN LEANDRO WATERSHED

Figure 6 (concl.)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

SECTION 4

ANALYSIS OF CASE STUDY APPLICATION

ABAG'S SURFACE RUNOFF MANAGEMENT ELEMENT

In June 1976, the U.S. Environmental Protection Agency awarded a grant to the Association of Bay Area Governments (ABAG) to prepare an Environmental Management Plan (EMP) for the San Francisco Bay Region, under Section 208 of the Federal Water Pollution Control Act Amendments of 1972. Surface Runoff Management was one of seven elements of the Plan. The ABMAC Model was one of the primary analytical tools used in the formulation of the Surface Runoff Management Element. It was also the first application of this model to a major areawide study under Section 208. In this section, the application of the early version of the model is described. Sections 5 and 6 highlight the refinements introduced to ABMAC as a result of this application.

Study Area Characteristics

The planning area represented by ABAG covers nine counties with the total of 7,000 square miles. 80 percent of this area drains directly into San Francisco Bay or its immediate tributaries (see Figure 7). By 1977 the area was home for 4.9 million residents, up 5.5 percent from 1970 and 83 percent from 1950 when the first attempts at comprehensive water quality protection were initiated.

The San Francisco Bay is by far the dominant hydrographic feature of the study area. It is also the "end-of-the-pipe" receptacle of most treated and untreated wastewater discharges of the region and, as such, it is a constant reflection of both good and bad wastewater management practices exercised at all levels of government, both within the region and over the full extent of the great Central Valley which drains into the Bay. Surface runoff quantity and quality is influenced by topography, soil type and land cover. The drainage network for the surface runoff includes over 40 major watershed ranging in size from just a few square miles to several hundred square miles.

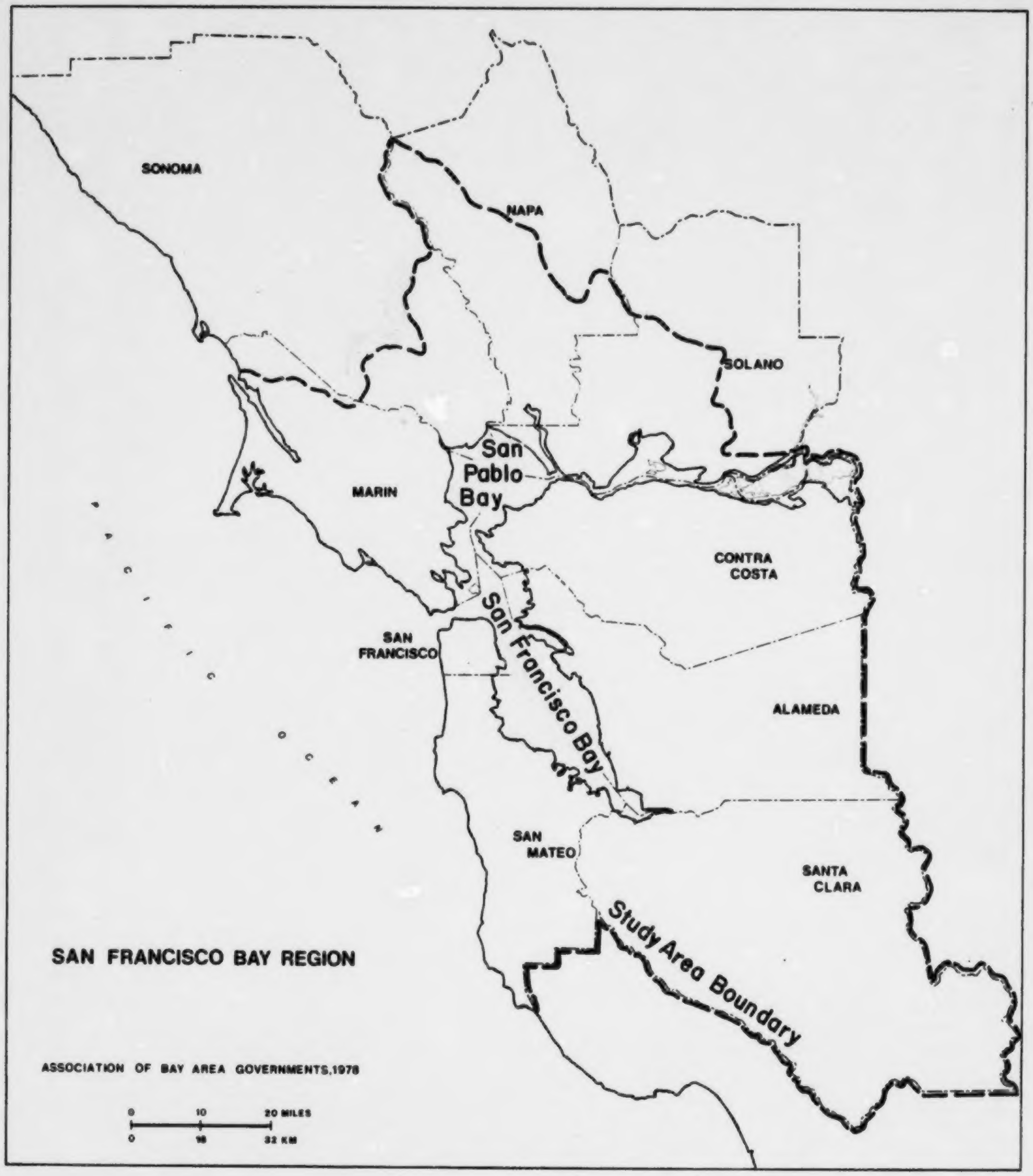
Program Goals

The goal for the Surface Runoff Management Element was the same as the goal for the entire Environmental Management Plan, namely, to produce a plan which:

- will lead to the greatest possible improvement in water quality;
- will not have social, economic, or environmental effects so unacceptable as to prevent implementation.

BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
BEGIN LAST LINE OF TEXT
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)


SONOMA
NAPA
SOLANO
San Pablo Bay
MARIN
CONTRA COSTA
PACIFIC OCEAN
SAN FRANCISCO
San Francisco Bay
ALAMEDA
SAN MATEO
SANTA CLARA
Study Area Boundary
SAN FRANCISCO BAY REGION
ASSOCIATION OF BAY AREA GOVERNMENTS,1978
0 10 20 MILES
0 16 32 KM

ABMAC STUDY AREA

Figure 7

There are two important aspects of this goal which affected the selection of the specific modeling approach described in this section. First, the primary purpose of the program was to solve, within a limited period of time, the environmental problems caused by surface runoff. The sophistication and accuracy of the selected modeling effort had to be, therefore, compatible with:

- the sensitivity of the control measures used in solving the identified problems and
- the overall availability and accuracy of data on water quality, land use, cost-effectiveness, etc.

A related issue which affected the needed level of modeling effort is the fact that not all problems are necessarily defined in terms of standards, and most of the existing standards are stated in general qualitative terms.

The second aspect of this goal was that it required a balancing of environmental, social, and economic benefits and costs. In selecting the appropriate modeling approach, recognition had to be given to this balancing process, which is in essence a political decision process. The extent to which the environmental benefits justify cost, and the degree to which the formulated plan can solve the problems requires, to a large extent, a value judgement as to the tolerability of the social and economic costs.

Concepts of Surface Runoff Modeling

The input required for plan development included adequate assessment of the following three elements:

- present pollutant loads by watersheds and counties
- future pollutant loads by watersheds and counties
- the expected reduction in present and future pollution loads as a result of instituting various mitigation measures.

The source of surface runoff pollutants and associated water quality problems involve three types of discharges: (1) combined sewer overflows, (2) surface runoff either collected seperately or occurring as nonsewered runoff, and (3) overflows of municipal wastewater resulting from excessive inflow/infiltration. Of the three types of discharges, the combined sewer overflows and overflows of infiltrated municipal wastewater have similar characteristics, with 5-day biochemical oxygen demand (BOD_5) loadings averaging approximately one-half the strength of untreated domestic sewage. This contrasts with surface runoff from urban areas which generally has been shown to have a BOD_5 of approximately the same strength as secondary effluent.

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD: BEGIN SECTIONS HERE

Despite this general information developed through an intensive data collection program, the surface runoff generated problems in the ABAG study area and the appropriate mitigation measures were difficult to assess because:

- The events are irregular and unpredictable;
- Other discharges or conditions tend to mask actual impacts;
- Relatively little usable data are available and new data are extremely time consuming and costly to obtain;
- Mitigation measures are largely conceptual and effectiveness is ill-defined; and
- Objective effluent criteria have not been specified (e.g., no waste load allocations have been set for surface runoff pollutants by receiving water segment).

6-1/2"

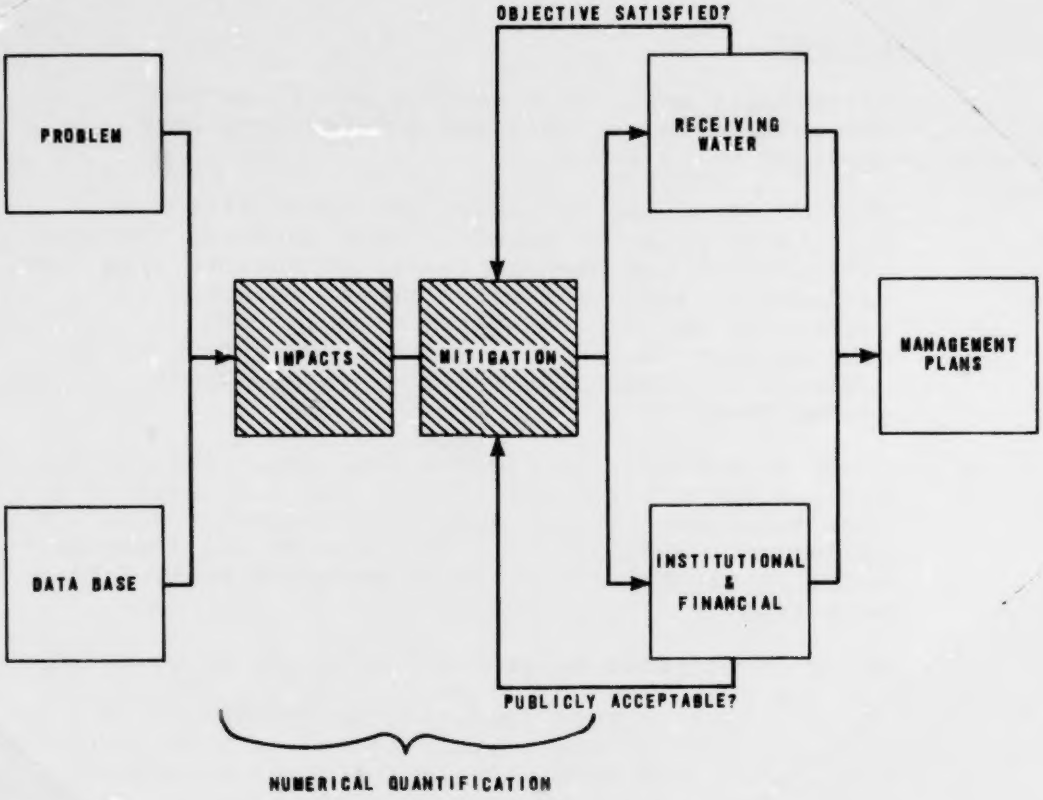
In the development of the modeling program all these factors had to be taken into account. The key program elements, which, working in combination, were used to produce the Surface Runoff Management Plan, are shown with their conceptual interrelationships in Figure 8. Basically, the models were used to compute and aggregate runoff loadings for comparison with point and other nonpoint discharges. The loadings are the products of flow and concentration and are expressed in average pounds per day over a specified time period.

The numerical quantification was accomplished through a dual modeling approach. The ABMAC model was used to look at broad areas and long periods of record. Precision was sacrificed for breadth of coverage and for speed and flexibility in model application. The second model, the Storm Water Management Model (SWMM) was applied to specific watersheds where control measures were to be assessed. The idea was to use these two models interactively, with ABMAC identifying the relative importance of major watershed towards specific problems, and SWMM providing the detailed examination and, in turn, outputting data which could improve the ABMAC assumptions.

It should be mentioned that in addition to the surface runoff model a receiving water simulation was used to represent the estuarine environment of San Francisco Bay and Delta. The model selected was a modified Link-Node Model, initially developed by Water Resources Engineers, Inc., and subsequently refined through repeated usage [3, 4, 9]. Of interest to this presentation is the fact that ABMAC model results were successfully used as input to the receiving water simulation. Figure 9 shows the networks for the entire San Francisco Bay with nodes indicated for which ABMAC results of surface runoff simulation were provided [5, 9].

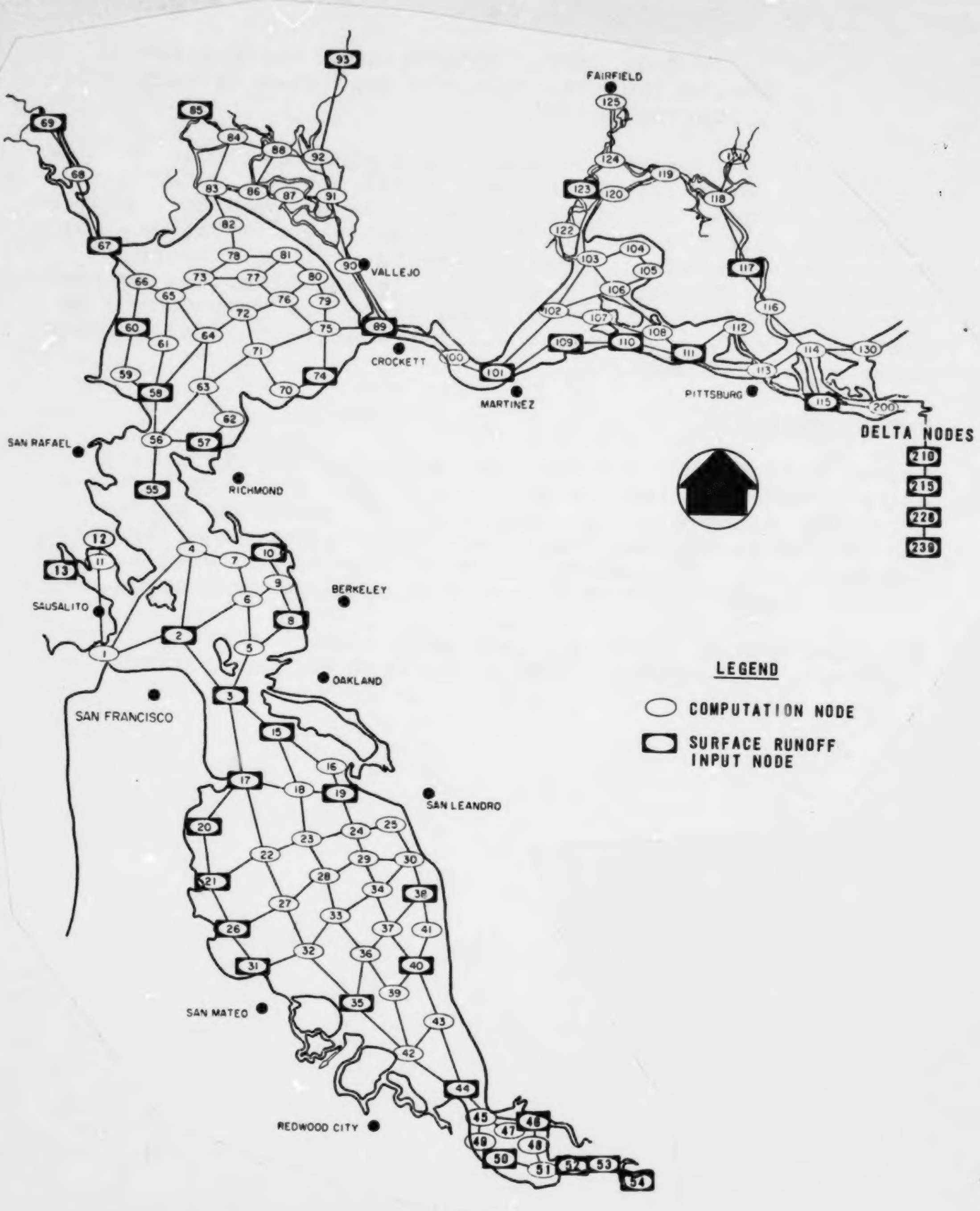
BEGIN LAST LINE OF TEXT
M OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)


OBJECTIVE SATISFIED?
PROBLEM
RECEIVING WATER
IMPACTS
MITIGATION
MANAGEMENT PLANS
DATA BASE
INSTITUTIONAL & FINANCIAL
PUBLICLY ACCEPTABLE?
NUMERICAL QUANTIFICATION

CONCEPT OF SURFACE RUNOFF MODELING

Figure 8


FAIRFIELD
VALLEJO
CROCKETT
MARTINEZ
PITTSBURG
DELTA NODES
210
215
228
239
SAN RAFAEL
RICHMOND
BERKELEY
SAUSALITO
OAKLAND
SAN FRANCISCO
SAN LEANDRO
SAN MATEO
REDWOOD CITY
LEGEND
COMPUTATION NODE
SURFACE RUNOFF INPUT NODE

INTERFACE OF ABMAC MODEL WITH THE SAN FRANCISCO BAY SIMULATOR

Figure 9

Control Measures

An important factor in evaluating the adequacy of any modeling approach is the nature of and the information available about the different control measures used in controlling surface runoff pollution problems. ABAG [2] has inventoried forty-two potentially applicable mitigation measures which are grouped into four general categories as follows:

- Group A -- Measures to reduce the accumulation of pollutants prior to runoff. This category includes; (1) alternatives designed to remove pollutants from land surfaces by actions such as street sweeping or stormwater collection system cleaning; and (2) alternatives designed to prevent deposition by controlling dumping or removing sewage cross-connections.

- Group B -- Measures to control land use. The various options for the control of land use are based on the fact that urban growth increases surface runoff and pollution. Regulation of the density and location of urban growth are alternative control measures.

- Group C -- Measures to reduce the amount of pollutants and the peak flow or volume of runoff. The alternatives in this group can be thought of as onsite control. The pollutants and as much runoff as possible are held back in the upper watersheds. The pollutants can be controlled by erosion prevention practices such as applying vegetative cover or proper construction practices. The volume of runoff is decreased by alternatives that maximize the pervious area and infiltration capacity of the basin.

- Group D -- Measures to treat and store runoff, including alternatives that treat stormwater runoff after it reaches the collection system and will usually require construction of capital intensive structures. The options can be categorized as on-line or off-line storage and treatment units.

The capability of the models to deal with these control measure is in many cases far from reliable. Figure 10 provides a subjective assessment of which of these control measures can be handled directly, indirectly, or cannot be handled at all.

Section 7 provides generalized recommendations for interfacing ABMAC with the control measures shown in Figure 10. As an example of model application for evaluating different control measures, the following three examples are provided:

Example 1: Maintenance measures are tested through the effectiveness of sweeping practices.

Control Measures	Handle Directly	Handle Indirectly	Cannot Handle
A. REDUCE ACCUMULATION OF POLLUTANTS			
1. Frequency of street sweeping	0		
2. Efficiency of street cleaning		0	
3. Repair streets to improve street sweeping		0	
4. Control use of certain chemicals		0	
5. Restrict auto parking		0	
6. Control use of lots and streets			0
7. Control dumping			0
8. Control littering and animal dropping		0	
9. Control air pollution emissions		0	
10. Control direct discharge of pollutants	0		
11. Clean stormwater collection system		0	
12. Replace cross connections	0		
13. Insure proper septic tank operation			0
B. CONTROL LAND USE			
1. Slope density standards	0		
2. Maintain open space areas	0		
3. Control development patterns	0		
4. Buffer strip requirements	0		
C. REDUCE AMOUNT OF RUNOFF			
1. Control roof drains	0		
2. Rooftop detention and storage	0		
3. Rechannel runoff		0	
4. Redesign curb and gutters		0	
5. Remove debris to improve flow		0	
6. Regrade disturbed areas	0		
7. Provide vegetative cover to bare slopes	0		
8. Stabilize channels			0
9. Control erosion at construction site		0	
10. Regulate construction schedule		0	
11. Construct permanent berms		0	
12. Use energy dissipaters in channels		0	
13. Increase perviousness of surfaces	0		
14. Minimize new impervious surfaces	0		
15. Improved tillage and plowing practices	0		
16. Modify drainage basin	0		
D. TREAT AND STORE RUNOFF			
1. Use catchbasins		0	
2. Impound runoff in channels	0		
3. Construct on-line and off-line storage	0		
4. Store runoff in storm sewers	0		
5. Construct treatment facilities	0		
6. Use existing treatment plants	0		
Prevent discharge to receiving water	0		

CAPABILITY of ABMAC / SWMM to ASSESS CONTROL MEASURES

Figure 10

Example 2: Potential effectiveness of erosion control practices are tested through installation of small control structures.

Example 3: Treatment measures are evaluated through the use of flood control basins/marsh areas for ponding and treatment of polluted surface runoff.

Representative results for the Calabazas Watershed in south San Francisco Bay Area are shown in Table 3. As shown in this table, it can be seen that if the pollutant (e.g., lead) is dominantly associated with street solids, improvements of sweeping efficiency will obviously be effective. However, where the source material is scattered throughout a watershed (e.g., SS) street sweeping may have negligible effect. Of the three, flood basin/marsh management appears extremely attractive.

TABLE 3. EFFECTS OF MITIGATION MEASURES[a]

Description	Net Flow Reduction (%)	Net Pollution Reduction (%)		
		BOD	SS	Lead
Example 1, street sweeping	0.0	13.7	3.0	27.3
Example 2, erosion control	0.0	>1.0	21.4[b]	>1.0
Exmple 3, flood basin/ marsh treatment[c]	0.0	31.6	59.5	26.3

a. Calabazas watershed 1975 conditions.
b. Some SWMM runs showed single storm improvements as high as 80%.
c. Flood basin relocated from Palo Alto to Calabazas watershed for purpose of example.

Source: [6].

Generally, it is not easy to establish the net pollution reduction of the various control measures. A substantial amount of research is currently directed towards establishing cost effectiveness information for the different control measures. As discussed further in this section, a convenient source of such information for ABAG application was the results of SWMM modeling conducted for site specific, demonstration watersheds. Table 4 provides a summary of results of SWMM mitigation measures assessment. It must be emphasized that the site specific mitigation measure studies conducted with SWMM give an indication of the relative effectiveness of street sweeping and erosion control alternatives on particular demonstration watersheds in the ABAG

TABLE 4. SUMMARY OF SWMM MITIGATION MEASURE ASSESSMENTS

Watershed type/control measures investigated	Summary of simulation results
Small urban watersheds (Glen Echo)	
Street sweeping	Suspended solids and BOD loads decrease almost linearly with increases in the number of passes per week. A street sweeping frequency of one pass per week could reduce coliform loads to Lake Merritt to about 25% of existing levels.
Roof top detention	The initial "first flush" peak of the BOD pollutograph is reduced by 30% when watershed-wide rooftop detention on commercial buildings is instituted. Coliform and solids loads appear to be reduced only slightly by this mitigation measure.
Medium mixed land use watersheds (Calabazas)	
Street sweeping	A twofold increase in number of passes per week throughout the watershed will give a 20-30% reduction in BOD loads and somewhat less in suspended solids. A larger increase (at least three-fold) will be needed to counterbalance anticipated increases in the county-wide BOD load due to population growth.
Erosion control	Improved maintenance of hillside grasslands and construction of small sedimentation basins in the upper watershed will reduce total suspended solids loading by nearly 80%.
Large rural watersheds (Sonoma, Napa)	
Erosion control	Installation of additional sedimentation basins in the upper reaches of either the Napa or Sonoma Creek watersheds could provide a significant (up to 60%) reduction in total solids load. If this mitigation measures were adopted in all major watersheds of the Napa and Sonoma valleys, a sizeable decrease in suspended solids loads delivered to San Pablo Bay during storm periods could be obtained.

Source: [2].

study area. The assessments of relative effectiveness provided by these studies can be generalized to other watersheds of similar size, land use, and hydrologic composition even though the absolute levels of contaminant reduction predicted may not be transferable. When the results of the SWMM mitigation measure evaluations are combined with those of ABMAC, a good indication of overall effectiveness (local and regional) can be obtained.

ABMAC APPLICATION

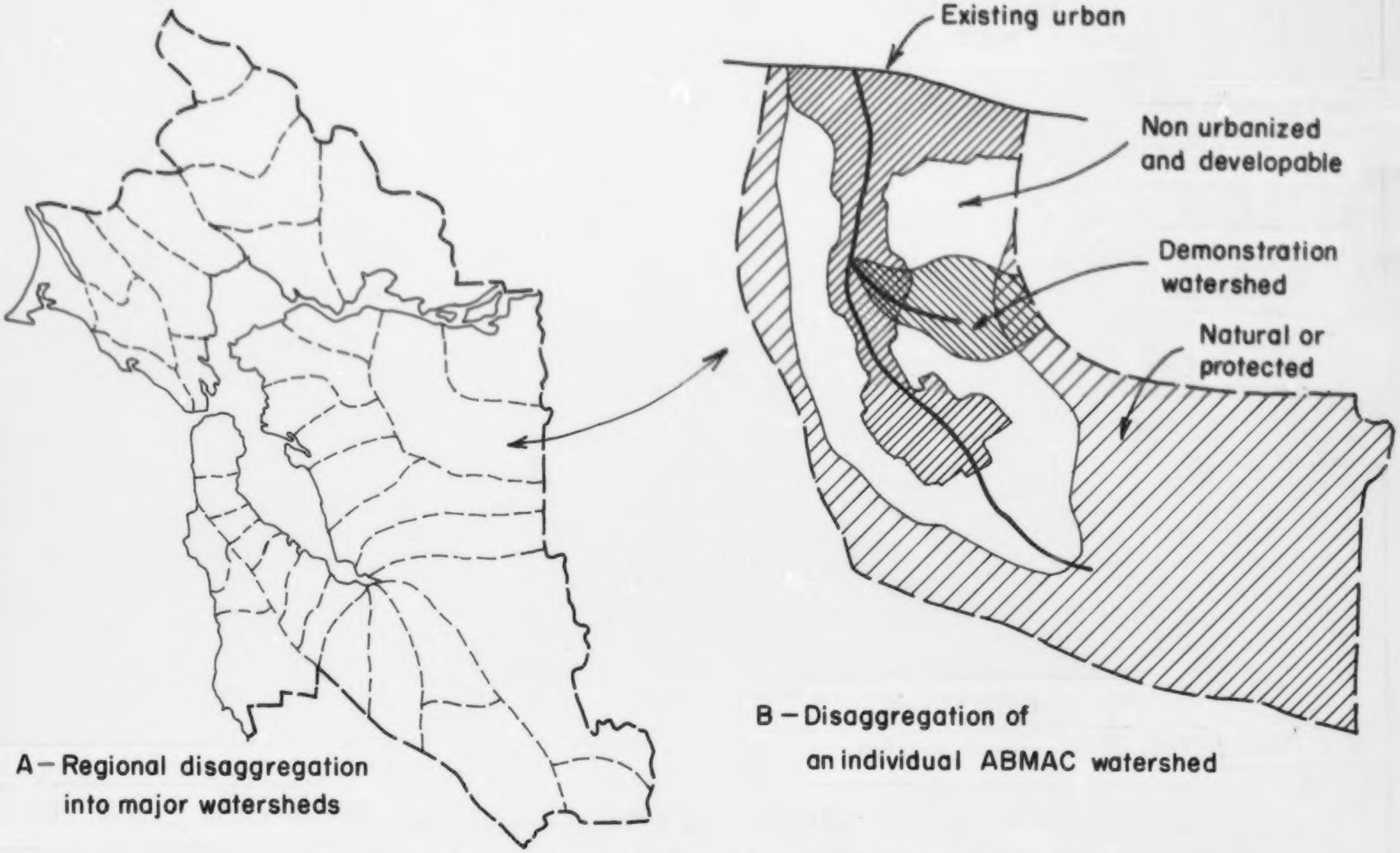
Model application began with the subdivision of the study area into areas of ultimate interest (major watersheds) and areas of special interest (demonstration watersheds) and the assignment of rainfall records appropriate to each subdivision. Quantity and quality data were estimated from available source data and subsequently calibrated to conditions of apparent "best fit." Finally, projections and mitigation measures were applied and impacts observed and interpreted.

Area Subdivision Into Modeling Units

The nine county study area was subdivided into 69 major watersheds of which 8 drain directly to the Pacific ocean, 59 drain to San Francisco Bay, and 2 drain via the Pajaro River to Monterey Bay. The average watershed area is 44,000 acres (69 sq. mi.) and the range is from 869 acres (1.4 sq. mi.) to 157,991 acres (247 sq. mi.). A schematic representation of regional disaggregation of major watersheds is shown in Figure 11. Each of the major watersheds was in turn subdivided into three types of subareas; Type A - natural or protected, Type B - nonurbanized but developable, and Type C - existing urban. Table 5 shows the major watersheds and subareas as classified for ABMAC use. Only in one county was a distinction made between agricultural use and open space. Thus, agricultural land use in the overall study area was generally understated. It is noteworthy that 87 percent of the total study area is classified as open or agricultural use, including 51 percent of the land identified as existing urban, or Type C. The remaining 13 percent is made up of residential (9 percent), commercial (2 percent), and industrial (2 percent).

Land Use and Population Data

The land use data, existing and projected, were developed by ABAG through its 440-zone planning model. The zones, 440 in number, are based on aggregations of census tracts. These zones are the basic analysis units used by ABAG and the Metropolitan Transportation Commission for regional projections of population, employment, and land use. The latest of these projections, called Series 3, with 1975 as a base year, were used in the ABMAC analyses. Transfer from 440 zone limits to ABMAC watersheds was facilitated by correspondence tables, ultimately developed into automatic programming [2]. Population data, existing and projected, were developed through the same mechanism as land use. A provisional set of projections showing high and low growth estimates is shown in Table 6.


Existing urban
Non urbanized and developable
Demonstration watershed
Natural or protected

A – Regional disaggregation into major watersheds

B – Disaggregation of an individual ABMAC watershed

AREA SUBDIVISION INTO MODELING UNITS

Figure 11

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
DROPPED SECTIONS HERE
CENTER OF PAGE
TOP OF IMAGE AREA

TABLE 5. MAJOR WATERSHED AND SUBAREA BASIC DATA FOR ABMAC ANALYSES

County and major watershed/subarea	Subarea classification[a]	Area, acres	Predominant system type[b]	Rainfall			Discharge location
				Gage ID	Transfer factor	Avg annual (1969-1970, 1970-1971 water year), in.	Bay model node, where applicable[c]
Alameda (Bayside)							
Berkeley	C	14,523	SEP	5	0.85	18.69	BN-008
Lake Merritt	C	20,808	SEP	5	0.85	18.69	BN-015
San Leandro	A	11,939	UNS	5	1.20	26.38	BN-019 via San Leandro and Lake Chabot Reservoir
San Leandro	C	20,029	SEP	5	0.70	15.39	BN-019
Hayward	A	15,381	UNS	5	1.05	23.08	BN-038
Hayward	B	6,708	SEP	5	0.90	19.79	BN-038
Hayward	C	43,304	SEP	5	0.80	17.59	BN-038
Lower Alameda Cr.	A	9,452	UNS	5	0.85	18.69	BN-040
Lower Alameda Cr.	B	6,558	SEP	5	0.90	19.79	BN-040
Lower Alameda Cr.	C	14,098	SEP	5	0.65	14.29	BN-040
Fremont	A	4,244	UNS	5	0.85	18.69	BN-046
Fremont	B	7,043	SEP	5	0.75	16.49	BN-046
Fremont	C	35,631	SEP	5	0.60	13.19	BN-046
Alameda (Upper Alameda Creek)							
Calaveras (U.A.Cr.)	A1	64,124	UNS	6	0.95	22.31	BN-040 via Calaveras Reservoir
Upper Alameda Cr.	A2	22,590	UNS	6	1.05	24.66	BN-040
Arroyo Valle (U.A.Cr.)	A3	86,627	UNS	6	0.85	19.96	BN-040 via Arroyo del Valle Reservoir
San Antonio (U.A.Cr.)	A4	27,973	UNS	6	0.95	22.31	BN-040 via San Antonio Reservoir
DeLa Laguna	A5	157,991	UNS	6	0.60	14.09	BN-040
Pleasanton	B	10,864	SEP	6	0.85	19.96	BN-040
Livermore	B	9,355	SEP	6	0.60	14.09	BN-040
Las Positas	B	5,643	SEP	6	0.60	14.09	BN-040
Pleasanton	C1	3,345	SEP	6	0.75	17.61	BN-040
Dublin	C2	6,534	SEP	6	0.80	18.79	BN-040
Livermore	C3	8,435	SEP	6	0.60	14.09	BN-040

BEGIN LAST LINE OF TEXT
3/8"
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
PAGE NUMBER
EPA-287 (Cin.)
(4-76)

TYPING GUIDE SHEET

BEGIN FIRST LINE OF TEXT HERE

DROPPED HEAD; BEGIN SECTIONS HERE

CENTER OF PAGE

TOP OF IMAGE AREA

				Rainfall			Discharge location
County and major watershed/subarea	Subarea classification[a]	Area, acres	Predominant system type[b]	Gage ID	Transfer factor	Avg annual (1969-1970, 1970-1971 water year), in.	Bay model node where applicable[c]
Contra Costa							
Marsh Creek	A	44,866	UNS	4	1.00	18.73	BN-215
Marsh Creek	B	25,981	UNS	4	0.70	13.11	BN-215
Kellog	A	41,059	UNS	4	0.80	14.99	BN-228
Walnut Creek	B	57,163	SEP	4	1.00	18.73	BN-109
Walnut Creek	C	33,954	SEP	4	1.00	18.73	BN-109
Diablo	B	20,131	SEP	4	1.00	18.73	BN-110
Diablo	C	6,858	SEP	4	1.00	18.73	BN-110
Alhambra	A	7,129	UNS	4	1.30	24.36	BN-101
Alhambra	B	1,628	SEP	4	1.10	20.61	BN-101
Alhambra	C	6,803	SEP	4	1.00	18.73	BN-101
San Pablo	A	22,244	SEP	4	1.10	20.61	BN-057 via San Pablo and Briones Reservoir
San Pablo	B	8,226	SEP	4	1.30	24.36	BN-057
San Pablo	C	8,468	SEP	4	1.00	18.73	BN-057
Pinole	A	13,986	SEP	4	1.30	24.36	BN-074
Pinole	B	10,371	SEP	4	1.00	18.73	BN-074
Antioch	A	6,291	UNS	4	0.80	14.99	BN-115
Antioch	B	4,947	SEP	4	0.70	13.11	BN-115
Antioch	C	7,959	SEP	4	0.70	13.11	BN-115
West Pittsburgh	A	7,721	UNS	4	0.70	13.11	BN-111
West Pittsburgh	C	16,205	SEP	4	0.90	16.86	BN-111
Upper San Leandro	A	16,735	SEP	4	1.60	29.90	BN-019 via San Leandro and Lake Chabot Reservoir
Richmond	C	12,339	SEP	4	1.20	22.48	BN-010
Delta Lowland	B	56,124	UNS	4	0.60	11.24	Delta
Marin							
Richardson Bay	C	14,321	SEP	1	1.30	38.41	BN-013
Corte Madera Cr.	C	17,932	SEP	1	1.60	47.27	BN-055
San Rafael	C	21,224	SEP	1	1.60	47.27	BN-058
Novato	C	29,318	SEP	1	1.10	32.50	BN-060
San Antonio Cr.	A	11,238	UNS	1	0.90	26.59	BN-067
Lagunitas Creek	A1	23,344	UNS	1	1.60	47.27	Ocean via Tomales Bay
Lagunitas Creek	A2-A4	35,248	UNS	1	1.50	44.32	Ocean via Tomales Bay via Nicasio Reservoir and Kent Lake

BEGIN LAST LINE OF TEXT

BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS

3/8"

PAGE NUMBER

EPA-287 (Cin.)
(4-76)

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
DROPPED HEAD; BEGIN SECTIONS HERE
CENTER OF PAGE
TOP OF IMAGE AREA

County and major watershed/subarea	Subarea classification[a]	Area, acres	Predominant system type[b]	Rainfall			Discharge location
				Gage ID	Transfer factor	Avg annual (1969-1970, 1970-1971 water year), in.	Bay model node where applicable[c]
Lagunitas Creek	A3	6,568	UNS	1	1.60	47.27	Ocean via Tomales Bay
Tomales Bay	A1	9,791	UNS	1	0.90	26.59	Ocean via Tomales Bay
Tomales Bay	A2	12,983	UNS	1	1.10	32.50	Ocean via Tomales Bay
Tomales Bay	A3	45,315	UNS	1	1.10	32.50	Ocean via Tomales Bay
Point Reyes	A	44,222	UNS	1	1.20	35.45	Ocean
Bolinas-Stinson	A	23,481	UNS	1	1.20	35.45	Ocean
Bolinas-Stinson	C	927	SEP	1	1.50	44.32	Ocean
Napa							
Upper Napa River	A	53,340	UNS	2	1.10	40.38	BN-093
Upper Napa River	B	12,304	UNS	2	1.00	36.71	BN-093
Upper Napa River	C	2,000	SEP	2	1.00	36.71	BN-093
Middle Napa River	A	78,504	UNS	2	1.00	36.71	BN-093
Middle Napa River	B	34,889	UNS	2	0.90	33.04	BN-093
Middle Napa River	C	9,935	SEP	2	0.80	29.37	BN-093
American Canyon	A	31,123	UNS	2	0.70	25.70	BN-093
American Canyon	B	11,966	UNS	2	0.70	25.70	BN-093
American Canyon	C	869	SEP	2	0.70	25.70	BN-093
Wooden Valley	A	28,427	UNS	2	0.90	33.04	BN-123
Wooden Valley	B	2,843	UNS	2	0.90	33.04	BN-123
Santa Clara							
Palo Alto-Mtn.View	A	33,862	SEP	7	2.50	31.09	BN-050
Palo Alto-Mtn.View	C	33,034	SEP	7	1.00	12.43	BN-050
Santa Clara, et al.	A	2,022	SEP	7	2.40	29.84	BN-052
Santa Clara, et al.	C	46,393	SEP	7	1.00	12.43	BN-052
San Jose southwest	A	33,992	UNS	7	2.40	29.84	BN-053 via Lexington, Guadalupe, Almaden, and Calero reservoirs
San Jose southwest	B	29,474	SEP	7	1.50	10.65	BN-053
San Jose southwest	C	46,758	SEP	7	1.00	12.43	BN-053
Coyote-Silver	A	141,183	UNS	7	1.60	19.90	BN-054 via Coyote Reservoir
Coyote-Silver	B	45,727	SEP	7	1.20	14.92	BN-054
Coyote-Silver	C	39,269	SEP	7	1.10	13.68	BN-054
Llagas-Uvas	A	66,095	UNS	7	1.50	18.65	Ocean via Pajaro River via Llagas and Uvas reservoirs
Llagas-Uvas	B	73,032	SEP	7	1.50	18.65	Ocean via Pajaro River
Pacheco	A	106,924	UNS	7	1.20	14.92	Ocean via Pajaro River

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
DROPPED HEAD; BEGIN SECTIONS HERE
CENTER OF PAGE
TOP OF IMAGE AREA
BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

County and major watershed/subarea	Subarea classification[a]	Area, acres	Predominant system type[b]	Rainfall			Discharge location
				Gage ID	Transfer factor	Avg annual (1969-1970, 1970-1971 water year), in.	Bay model node where applicable[c]
San Francisco							
San Francisco S.E.	C	8,758	COM	9	1.00	19.79	BN-017
San Francisco N.Pt.	C	5,717	COM	9	1.00	19.79	BN-003
San Francisco N.Shr.	C	3,062	COM	9	1.00	19.79	BN-002
San Francisco R-S	C	10,991	COM	9	1.00	19.79	Ocean
San Mateo							
Pacifica	C	12,792	SEP	8	1.30	24.82	Ocean
Brisbane	B	4,431	SEP	8	1.10	21.00	BN-020
So.San Francisco	C	11,076	SEP	8	1.30	24.82	BN-021
Millbrae-Burlingame	C	10,564	SEP	8	1.40	26.73	BN-026
San Mateo Creek	A	22,419	UNS	8	1.80	34.36	BN-031 via Crystal Springs and San Andres Reservoir
San Mateo Creek	C	7,717	SEP	8	1.30	24.82	BN-031
Belmont-Atherton	C	30,742	SEP	8	1.10	21.00	BN-035
San Francisquito	A	22,320	UNS	8	1.40	26.73	BN-044
San Francisquito	C	7,091	SEP	8	1.00	19.09	BN-044
Pescadero Creek	A	112,978	UNS	8	1.60	30.54	Ocean
Half Moon Bay	A	37,637	UNS	8	1.80	34.36	Ocean
Half Moon Bay	B	3,192	SEP	8	1.10	21.00	Ocean
Solano							
Vallejo-Benicia	A	22,485	UNS	3	0.90	16.96	BN-089
Vallejo-Benicia	B	8,703	SEP	3	0.90	16.96	BN-089
Vallejo-Benicia	C	15,616	SEP	3	0.90	16.96	BN-089
Fairfield-Suisan	A	61,371	UNS	3	1.00	18.84	BN-123
Fairfield-Suisan	B	10,987	SEP	3	1.00	18.84	BN-123
Fairfield-Suisan	C	9,551	SEP	3	1.00	18.84	BN-123
Collinsville	A	83,877	UNS	3	0.85	16.01	BN-117
Collinsville	B	7,155	UNS	3	0.85	16.01	BN-117
Sonoma							
Glen Ellen	A	24,027	UNS	1	1.20	35.45	BN-085
Glen Ellen	B	12,898	UNS	1	1.20	35.45	BN-085
Glen Ellen	C	941	SEP	1	1.20	35.45	BN-085
Sonoma	A	14,613	UNS	1	1.10	32.50	BN-085
Sonoma	B	18,870	UNS	1	1.10	32.50	BN-085

EPA-287 (Cin.)
(4-76)

TYPING GUIDE SHEET

County and major watershed/subarea	Subarea classification[a]	Area, acres	Predominant system type[b]	Rainfall			Discharge location
				Gage ID	Transfer factor	Avg annual (1969-1970, 1970-1971 water year), in.	Bay model node where applicable[c]
Sonoma	C	1,883	SEP	1	1.10	32.50	BN-085
Bayside	A	19,364	UNS	1	0.70	20.68	BN-085
Bayside	B	17,131	UNS	1	0.70	20.68	BN-085
Penngrove	A	2,694	UNS	1	0.90	26.59	BN-069
Penngrove	B	16,231	UNS	1	0.90	26.59	BN-069
Penngrove	C	1,044	SEP	1	0.90	26.59	BN-069
Petaluma Valley	A	4,017	UNS	1	1.00	29.54	BN-069
Petaluma Valley	B	12,077	UNS	1	1.00	29.54	BN-069
Petaluma Valley	C	2,817	SEP	1	1.00	29.54	BN-069
Petaluma River	A	9,881	UNS	1	0.90	26.59	BN-069
Petaluma River	B	20,178	UNS	1	0.90	26.59	BN-069
San Antonio Marin	A	8,092	UNS	1	0.90	26.59	BN-067
San Antonio Marin	B	6,518	UNS	1	0.90	26.59	BN-067

a. A - Natural or protected
B - Potentially developable
C - Existing urban
Whenever more than one district area was identified it was denoted by a sequential numeral following subarea classification (for example A1)

b. SEP - Separate storm and sanitary sewers
UNS - Predominately open drainage and culverts
COM - Combined storm and sanitary sewers

c Refer to Figure 9.

Source: [6].

EPA-287 (Cin.)
(4-76)

TABLE 6. POPULATION PROJECTIONS
(All data in 1000s)

		1990	
County	1975	High	Low
Alameda	1,089.9	1,180.3	1,163.4
Contra Costa	582.8	774.3	690.5
Marin	216.1	251.9	237.2
Napa	90.0	109.0	90.3
San Francisco	672.6	641.9	645.1
San Mateo	576.4	606.1	597.0
Santa Clara	1,169.7	1,367.0	1,352.0
Solano	186.3	345.6	227.5
Sonoma	245.4	345.9	280.6
Region total	4,829.2	5,621.9	5,283.7

Source: [1].

Rainfall Network

To account for rainfall variability over the study area, daily historical rainfall records were collected from nine primary U.S. Weather Bureau rain gages distributed within the study area. Source of the rainfall tapes was the National Climatic Center, NOAA Environmental Data Service, Federal Building, Asheville, North Carolina 28801. The rainfall records were adapted for direct model input, typically six card images per year, and logged in the user support library under the appropriate code identifiers. The data generally span the period 1948-1975. From the complete set, two water years, 1969-1970 and 1970-1971, were selected as repesentative of "average" conditions and used in the preliminary analyses.

Demonstration Watersheds

To augment the regional, rather coarse, analysis by major watersheds and to concentrate most effectively a very small monitoring budget within a limited time frame, several "demonstration watersheds" were selected, each representing a particular type of watershed found throughout the region. These demonstration watersheds were subsequently set up for runs using the site specific model. In the San Francisco Bay region, most watersheds can be grouped into one of the following categories:

- o Small urban watersheds -- highly developed, high runoff coefficents, sewered

- Medium-size, mixed land use watersheds -- usually developed downstream and undeveloped upstream, runoff coefficients dependent on soil moisture conditions

- Large, undeveloped watersheds -- rural watersheds with some *development in valleys*, relatively low runoff coefficients, significant sedimentation

A number of candidate watersheds in each category were identified early in the program. After consideration of data availability, potential water quality problems, suitability for monitoring and site specific modeling, and the degree of local interest, a final set of 12 watersheds was selected. General information on these 12 demonstration watersheds is listed in Table 7. Their locations are noted in Figure 12. A quick review of the summary tables shows that the demonstration watersheds differ considerably in size, demographic characteristics, and hydrology. As a group, they provide a reasonably representative cross-section of surface runoff conditions in the San Francisco Bay Area. The details of steps in site specific modeling with SWMM are not discussed here and the researcher is referred elsewhere [6, 9]. Definition of the drainage network and hydrologic subareas (often called subcatchments) was completed for each of the 12 San Francisco Bay demonstration watersheds. Figure 13 shows, as an example, the subcatchment boundaries, pipes or stream channels, and flow gauge locations used to characterize one of the 12 watersheds for simulation with SWMM.

Quantity Coefficients For Modeling

ABMAC is structured to compute runoff as a direct multiple (K) of rainfall and includes the option of varying the K factor with land use. A runoff coefficient for a paved parking lot may be 0.95 whereas for a field under cultivation, it may be 0.05. However, these coefficients once set are held constant. They do not reflect how wet or dry the particular surface was just prior to the storm. The result is a tendency to overestimate runoff in dry years and underestimate runoff in wet years. The starting coefficients for initial calculations are shown in Table 8. Improved estimates were obtained by matching up average runoff yields against average annual rainfall on a watershed by watershed basis.

TABLE 8. ABMAC RUNOFF COEFFICIENTS, INITIAL VALUES

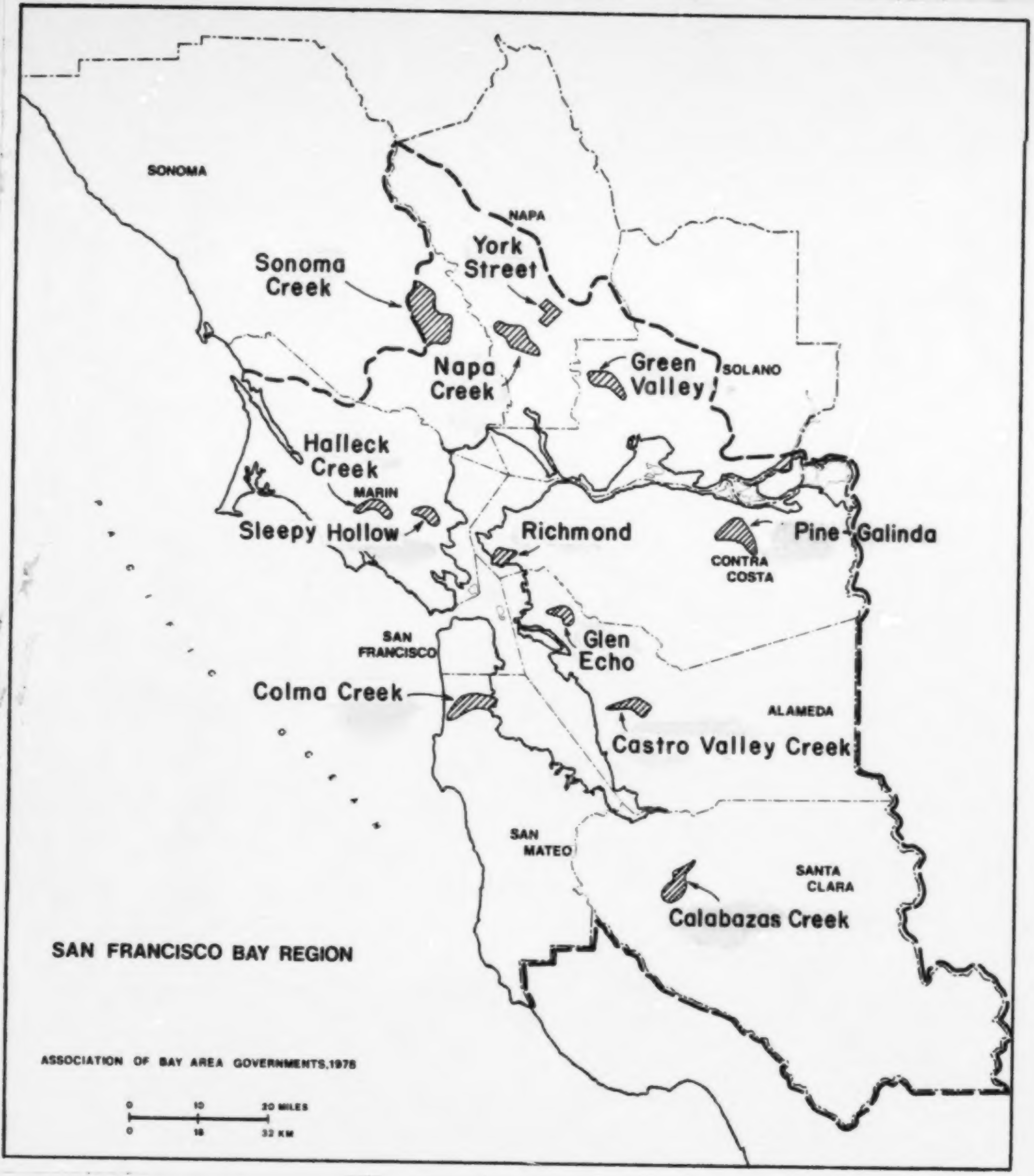
Land Use	K Factor
Residential	0.3
Multifamily Residential	0.4
Commercial	0.7
Industrial	0.6
Open	0.2
Agricultural	0.1

Source: [2].

TABLE 7. GENERAL INFORMATION ON DEMONSTRATION WATERSHEDS SELECTED FOR SITE-SPECIFIC ANALYSIS

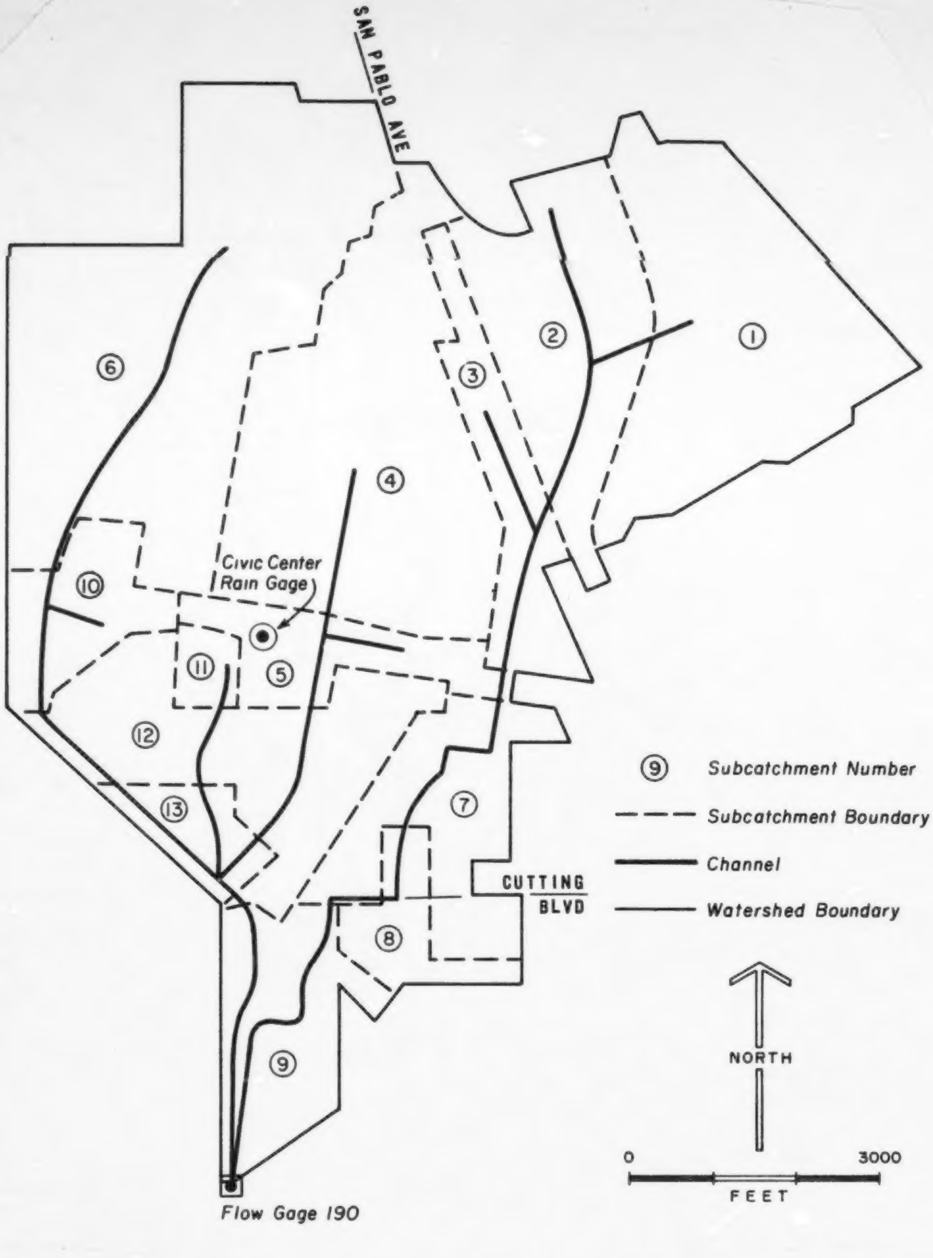
Watershed	County	Size, mi^2	Land use and cover	Potential surface runoff problems	Relevant mitigation measures which could be evaluated with SWMM
Small urban watershed					
Glen Echo Creek	Alameda	2.0	Mostly high density residential except along commercial arteries. Watershed includes a golf course and cemetary.	Solids, grease, etc. from streets and possible infiltration of storm flows.	Street-sweeping alternatives
Richmond	Contra Costa	2.5	Heavily developed warehouse and commercial area in downstream portion. Otherwise high density residential.	Solids, grease, and industrial pollutants from warehouse and commercial areas.	Street-sweeping alternatives.
Napa York St.	Napa	0.2	Medium density residential.	No significant problems identified.	---
Medium-size mixed land use watersheds					
Castro Valley Creek	Alameda	5.5	Includes central commercial area of Castro Valley and surrounding medium density housing.	Solids, grease, etc. from streets. Some commerical pollutnats.	Street-sweeping alternatives.
Sleepy Hollow Creek	Marin	2.2	Low density residential area.	No significant problems identified.	---
Calabazas Creek	Santa Clara	14.2	Heavy residential and commercial downstream development is gradually spreading up the hills.	Sedimentation upstream. Solids and grease from developed downstream areas.	Erosion control and street-sweeping.
Colma Creek	San Mateo	10.5	Heavily developed except on slopes of San Bruno mountain. Extreme downstream area is industrial.	Sedimentation, solids and grease from developed areas.	Street-sweeping.
Pine-Galinda	Contra Costa	28.3	Upstream area undeveloped park and grazing land. Suburban development in lower portions, including commercial strips with higher densities.	Sedimentation, nutrients from grazing, solids and grease from developed areas.	Erosion control and street-sweeping.
Large undeveloped watersheds					
Halleck Creek	Marin	8.8	Completely undeveloped. Some grazing land with forested strips along Halleck and tributary creeks.	Some natural sedimentation.	---
Napa Creek	Napa	15.4	Light development along creek. Heavily forested upstream areas. Some grazing.	Sedimentation.	Erosion control.
Sonoma Creek	Sonoma	58.2	Small towns and light residential development on valley floor. Some agriculture and grazing on hills.	Sedimentation.	Erosion control.
Green Valley Creek	Solano	21.6	Land use and cover similar to Napa Creek watershed.	Sedimentation.	Erosion control.

Source: [2].


SONOMA
NAPA
York Street
Sonoma Creek
Napa Creek
Green Valley
SOLANO
Halleck Creek
MARIN
Sleepy Hollow
Richmond
Pine-Galinda
CONTRA COSTA
SAN FRANCISCO
Glen Echo
Colma Creek
ALAMEDA
Castro Valley Creek
SAN MATEO
SANTA CLARA
Calabazas Creek
SAN FRANCISCO BAY REGION
ASSOCIATION OF BAY AREA GOVERNMENTS,1978
0 10 20 MILES
0 16 32 KM

LOCATION OF DEMONSTRATION WATERSHEDS SELECTED FOR SITE-SPECIFIC ANALYSIS

Figure 12


SAN PABLO AVE
①
②
③
④
⑤
⑥
⑦
⑧
⑨
⑩
⑪
⑫
⑬
Civic Center Rain Gage
CUTTING BLVD
⑨ Subcatchment Number
Subcatchment Boundary
Channel
Watershed Boundary
NORTH
0
3000
FEET
Flow Gage 190

RICHMOND DEMONSTRATION WATERSHED

Figure 13

Quality Coefficients From National Sources

National experience in surface runoff monitoring is available from several sources. Three of the more comprehensive analyses are excerpted below.

- The quality of urban runoff has been investigated at several sites across the country. The techniques, methodology, and goal varied from project to project, but the combined results present a good indication of the concentrations of pollutants that can be expected in urban runoff. The results of several representative sampling efforts are shown in Table 9. The samples were taken in various parts of the country, from diverse land uses, during different seasons, and during dissimilar rainfall events. The average pollutant concentrations shown in the table indicate an order of magnitude for the stormwater runoff problem. The ranges illustrate the wide variation in concentrations that may be anticipated. Averages were drawn from over 2,500 samplings [8].

TABLE 9. POLLUTANT CONCENTRATIONS IN STORMWATER RUNOFF

	Average pollutant concentrations, mg/L									
City	TSS	VSS	BOD	COD	Kjeldahl nitrogen	Total nitrogen	Total phosphorus	OPO_4-P	Lead	Fecal coliforms[a]
Atlanta, Georgia	287	--	9	48	0.57	0.82	0.33	--	0.15	6,300
Des Moines, Iowa	419	104	56	--	2.09	3.19	0.56	0.15	--	--
Durham, North Carolina	1,223	122	--	170	0.96	--	0.82	--	0.46	230
Knoxville, Tennessee	440	--	7	98	1.9	2.5	0.63	0.32	0.17	25,600
Oklahoma City, Oklahoma	147	--	22	116	2.08	3.22	1.00	1.00	0.24	40,000
Tulsa, Oklahoma	367	--	12	86	0.85	--	--	0.38	--	420
Santa Clara, California	284	70	20	147	--	5.8	0.23	--	0.75	--
Pullach, Germany	158	53	11	125	--	--	--	--	--	--
Average (not weighted)	415	88	20	113	1.41	3.11	0.62	0.46	0.35	14,500
Range	147-1,223	53-122	7-56	48-170	0.57-2.09	0.82-5.8	0.33-1.00	0.15-1.00	0.15-0.75	230-40,000

a. Organisms/100 mL.

Source: [8].

- Another study [11] subjected the data from 20 cities and background values to statistical analysis with the results shown in Table 10.

TABLE 10. SUMMARY OF STORMWATER POLLUTANT CONCENTRATIONS

	Average pollutant concentrations, mg/L				
	TSS	BOD	COD	Total nitrogen	Total phosphorus
20 cities, storm sewers and unsewered areas					
Mean	608	27	205	2.3	0.5
Standard deviation[a]	616	25	118	1.4	0.4
Background from virgin land					
Range	2-100	0.5-3.0	--	0.05-0.5[b]	0.0-0.2

a. Approximately 70% of all values fall within the mean plus or minus one standard deviation.

b. Inorganic only.

Source: [11].

- In a third study, the University of Florida and the American Public Works Association produced for the EPA a "Nationwide Characterization" that further identified a runoff quality breakdown by land use and population density [12], which has been incorporated into ABMAC. There are some differences, however, due to data corrections, assumptions of runoff volume, and addition of undeveloped areas in ABMAC. Comparisons for an assumed population density of 20 persons/acre are shown in Table 11.

Local Monitoring

The hydrological year 1976/77, when the ABAG study was conducted, was one of the worst drought years in California's history. In spite of the difficulties imposed by the drought, the first extensive surface runoff monitoring program was carried out involving 8 of the 9 counties. The test areas, storms, and samples are summarized in Table 12. The available results through May 15, 1977, were averaged and grouped by predominant land use with the results shown in Table 13.

Model Calibration

ABMAC calibration required local data and was performed in two steps: quantity and quality. Refinement of the model parameters was a continuing process due to overlapping programs of research, Series-3 projection development, site monitoring, and test applications. As

TABLE 11. COMPARISON BETWEEN UNCALIBRATED ABMAC AND REPORTED NATIONAL AVERAGE VALUES BY LAND USE

Average Pollutant Concentrations (mg/l)

Land use	BOD		TSS		VSS		PO_4[a]		N[b]	
	ABMAC	Nat	ABMAC	Nat	ABMAC	Nat	ABMAC	Nat	ABMAC	Nat
Resid.	12.9	14.6	262	297	153	174	0.6	0.6	8.7	2.4
Comm.	41.5	20.2	288	140	182	88	1.0	0.5	3.8	1.9
Indus.	15.8	8.9	378	214	187	105	0.9	0.5	3.6	2.0
Other devel.	-	0.7	-	17	-	16	-	0.1	-	0.4
Other devel. and undevel.	0.2	-	5	-	5	-	0.0	-	0.1	-

a. As P. b. As N.

Source: [2].

TABLE 12. ABAG MONITORING TEST AREAS

County	Watershed	No. storms	No. samples	Land use, %				
				Residential	Commercial	Industrial	Open	Agriculture
Alameda	Richmond	3	50	76	12	8	4	--
	Glen Echo	5	40	57	11	0	32	--
	Castro Valley	5	33	--	--	--	--	--
	Peralta	--	26	--	--	--	--	--
Contra Costa	Walnut Creek	5	9	35	13	2	50	--
	Pine Creek	5	11	24	1	1	74	--
	SR Rudgear	1	1	6	--	--	94	--
	SR @ WC	1	3	20	8	--	72	--
	Rheem	1	4	77	13	2	7	--
	Galindo	1	1	15	--	--	85	--
	LPC	1	1	--	--	--	100	--
Marin	Sleepy Hollow	4	41	20	--	--	80	--
Napa	York St	4	22	90	--	--	10	--
	Napa Creek	5	14	10	--	--	75	15
Santa Clara	Calabazas	5	65	38	14	2	46	--
	Santa Clara	3	40	--	--	100	--	--
	San Jose	3	36	--	100	--	--	--
	Guadalupe	2	25	33	11	3	54	--
	Matadero	3	28	--	--	100	--	--
	Berryessa	7	65	19	6	2	73	--
Solano	Green Valley	1	8	1	--	--	86	12
Sonoma	Sonoma Creek	2	6	2	0.4	0.6	89	8
San Mateo	Colma	1	1	27	9	12	52	--
	Serramonte	1	1	81	10	0	9	--
	Bay Front	1	1	--	20	80	--	--
	Brewster	1	1	100	--	--	--	--

Source: [2].

TABLE 13. LOCAL MONITORING RESULTS GROUPED BY PREDOMINANT LAND USE

Concentrations, mg/l

Residential	%	Samples	BOD	SS	VSS	Total N	Total P	Population Density
Alameda								
Castro Valley								
1971-1972	70 (?)	36	6.7	904	-	2.0	0.7	-
1972-1973	-	59	31.0	945	-	3.7	0.8	-
1976-1977	70	33	25.7	339	-	-	-	21.4
Glen Echo	57	40	40.3	227	-	-	-	26.1
Peralta	-	26	24.9	-	-	2.7	0.7	-
Richmond	76	50	19.8	115	39	3.2	0.4	21.7
Contra Costa								
Pine Creek	24	11	-	-	-	-	-	-
Rheem	77	4	21.0	211	28	4.5	0.6	-
San Ramon at Walnut Cr.	20	3	8.5	129	19	1.4	0.4	-
Walnut Creek	35	9	8.8	132	23	2.7	0.6	11.4
Napa								
York Street	90	22	22.0	81	36	1.2	0.4	14.0
San Mateo								
Brewster	100	1	7.0	145	54	3.5	0.02	14.0
Colma	27	1	16.0	207	43	3.5	0.3	-
Serramonte	81	1	14.0	85	28	1.3	0.2	-
Santa Clara								
Calabazas	38	65	19.4	557	88	4.5	0.9	18.2
Guadalupe	33	25	27.0	461	98	6.4	0.8	16.7
Commercial								
Santa Clara-San Jose	100	36	21.1	158	67	7.0	0.7	-
Industrial								
Matadero	100	28	38.1	72	21	3.1	0.4	-
Santa Clara	100	40	13.0	114	45	4.5	0.3	-
San Mateo-Bay front	80	1	16.0	90	26	1.3	0.2	-
Open								
Contra Costa-SR-Rudgear	94	1	6.8	220	38	3.8	0.6	-
Contra Costa-Little Pine	100	1	9.7	5200	550	2.6	2.4	-
Marin-Sleepy Hollow	80	41	4.3	87	16	2.4	0.2	-
Santa Clara-Berryessa	73	65	8.0	1134	146	3.6	1.0	-
Open and Agricultural								
Napa-Napa Creek	90	14	13.0	1053	128	5.1	0.6	-
Solano-Green Valley	98	8	-	85	-	3.4	0.2	-
Sonoma-Sonoma Creek	97	6	4.0	6	5	2.1	0.3	-

a. 4 days after storm

Source: [2].

would be expected, ABMAC calibration emphasized judgmental decisions. Initially one or more demonstration watersheds were used. The objective was to approximate annual average values and to test transferability. For example, in Santa Clara County, the Calabazas Creek (9,070 acres) watershed was used for calibration in conjunction with directly measured runoff from representative land use types. In the process, runoff coefficients were fixed for commercial and industrial areas based on the 1976-1977 season's observations.

Next, open and undeveloped area runoff was matched to the USGS estimate for the region and a set of both larger and smaller values. For each assumption, the residential (predominant land use) runoff was computed as the best (least squares) fit using 15 years of composite stream gage data. The resulting best overall fit is shown for long term (yearly) and short term (monthly) comparisons in Figures 14 and 15.

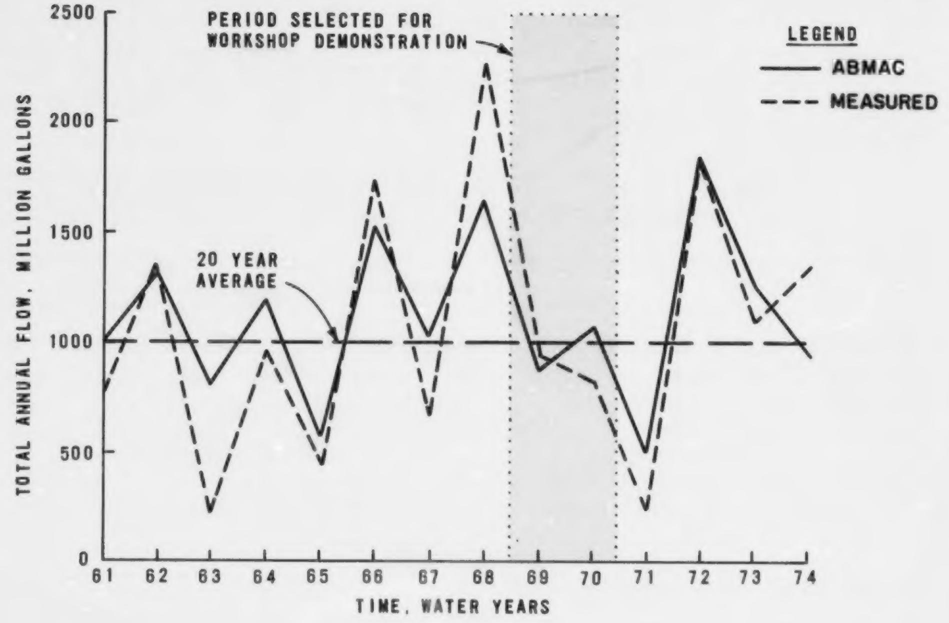
For quality calibration, flow weighted and arithmetic averages by sampling location were computed for the 259 samples collected within the county. Three of the test areas represent single land uses. Thus, the flow weighted concentrations could be substituted directly into ABMAC. These included commercial, industrial (light) and industrial (heavy). Because the 1976-1977 drought conditions yielded no measurable runoff from undeveloped open areas, the adjustments between residential and open were made by weighing both the national data and the composite area local results. Results from the three data sets (initial ABMAC, revised National, and calibrated ABMAC) are shown with the measured values for the Calabazas Creek watershed in Table 14.

TABLE 14. COMPARISON OF ABMAC RESULTS TO MEASURED VALUES IN CALABAZAS WATERSHED
(Concentrations in mg/l)

Item	Gross runoff, %	BOD	SS	VSS	Total N	Total P
Initial MAC	34.7	18.7	229	136	2.3	0.6
Revised National	27.2	13.5	174	104	1.7	0.5
Calibrated MAC	23.0	12.7	318	68	4.1	0.7
Measured 1976-1977	10.9	19.4	557	88	4.5	0.9
Measured (15-yr avg)	23.0	--	--	--	--	--

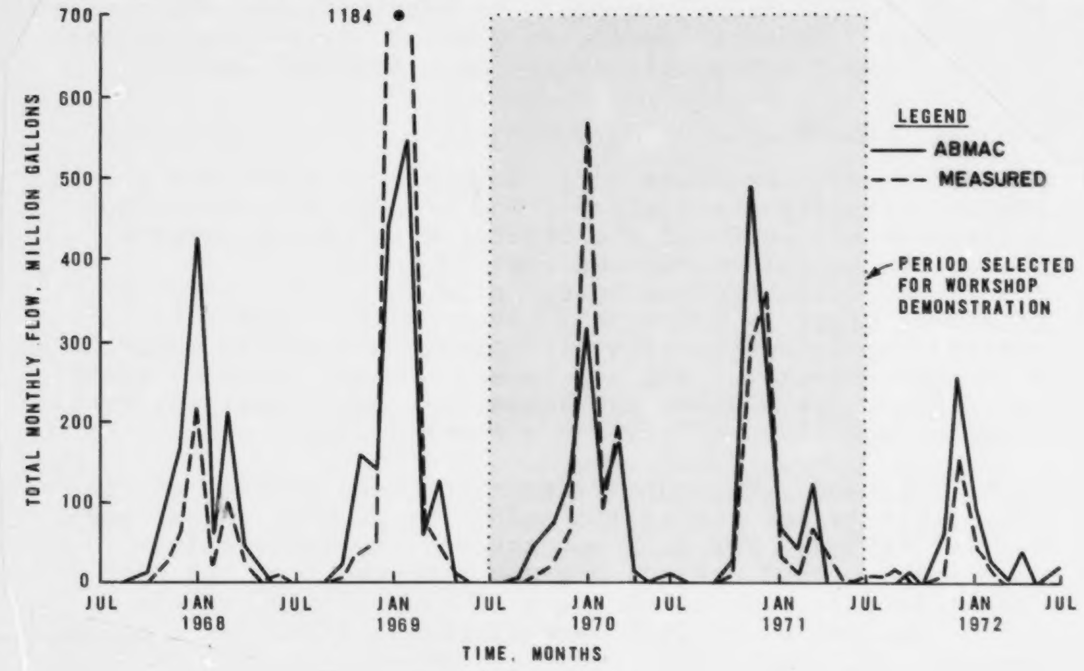
Source: [2].

Calibrated ABMAC was also run on a second watershed of comparable area, Berryessa. These results are compared to measured values in Table 15.



LONG-TERM COMPARISON
OF ABMAC WITH MEASURED VALUES

Figure 14



SHORT-TERM COMPARISON
OF ABMAC WITH MEASURED VALUES

Figure 15

TABLE 15. CALIBRATED ABMAC TRANSFERRED TO BERRYESSA WATERSHED
(Concentrations in mg/l)

Item	Gross runoff, %	BOD	SS	VSS	Total N	Total P
Calibrated MAC	16.8	8.5	430	63	2.5	0.4
Measured 1976-1977	4.9	8.0	1,134	146	3.6	1.0
Measured (5-yr avg)	34.0	--	--	--	--	--

Source: [2].

In spite of the greatly simplified representation of real world phenomena, these ABMAC projections appear to be well within the order of magnitude assessment objective for certain parameters of interest, e.g., BOD and nutrients. Compared on an annual loading basis, the extreme range between test assumptions (high divided by low) is approximately 2 to 1 for all parameters. The high measured suspended solids concentration for developed areas was believed to be related to the short duration of the drought storm events, when sustained periods of relatively dilute runoff were rarely experienced.

The results of the calibration trials and the 1976-1977 monitoring program were reviewed by the counties and ABAG staff and reduced to a working but still flexible consensus. The values in Table 16 are representative of regional values, but are heavily handicapped by the abnormal rainfall/runoff conditions during sampling, which was carried out during one of the most severe 2-year drought in California history. This abnormality is particularly evident in the SS and VSS coefficients shown for the open and agricultural lands.

TABLE 16. ABMAC QUALITY COEFFICIENTS FOR REGIONAL ANALYSIS
(Concentrations in mg/l)

Land use	BOD	SS	VSS	Total N	Total P
Residential	15	200	50	3.5	0.4
Residential, multifamily	20	300	75	3.0	0.3
Commercial	20	150	70	5.0	0.7
Industrial	13	120	50	3.0	0.5
Open	2	400	60	0.6	0.05
Agricultural	4	600	90	2.5	0.2

Source: [2].

Modeling Results

The ABMAC Modeling results provide the following information as input to the development of the Surface Runoff Management Plan for the San Francisco Bay Area:

1. Existing and Projected Pollutant Loadings - Information for five parameters (BOD_5, Suspended Solids, Total Nitrogen and Total Phosphorus) was developed for each of the nine Bay Area counties. The results allowed the development of the following general conclusions:

   - Surface runoff loadings on a regional scale do not change dramatically in projections to 1985 and 2000.

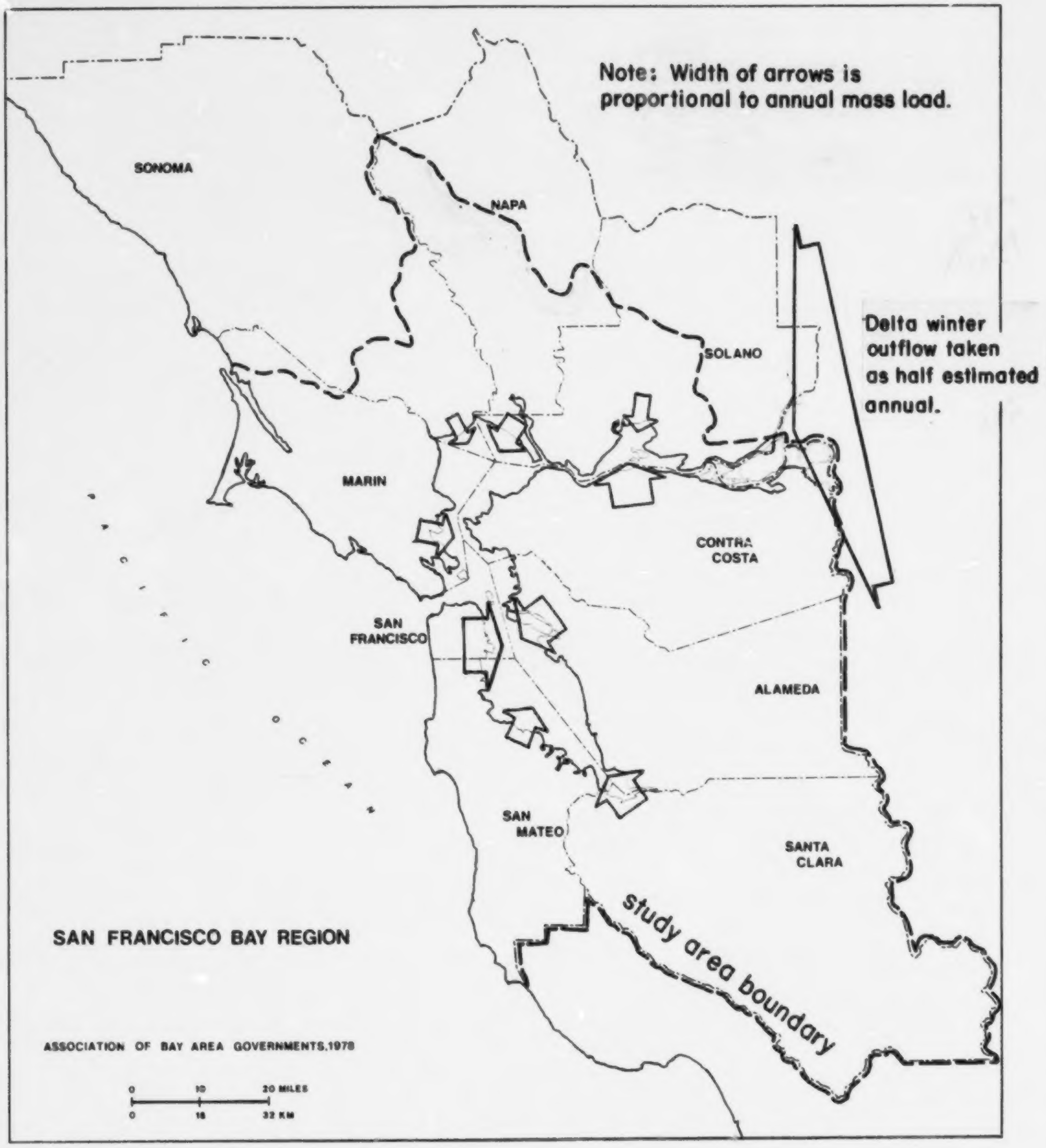
   - Surface runoff loadings in terms of BOD_5 are relatively small when compared to point source discharges today, but will nearly equal point sources when full secondary treatment of point sources is in effect.

   - Surface runoff loadings in terms of nutrients are nominally 5 to 15 percent as great as point sources, but can prove to be a major factor in the eutrophication of inland lakes and reservoirs where point sources are absent.

   - Surface runoff loadings are a major source of suspended solids and sediment in the Bay and its tributaries, but even greater loadings are introduce through Delta outflows.

2. Mitigation Measures Assessment - The site specific mitigation measure studies conducted with SWMM provide an indication of the relative effectiveness of street sweeping and erosion control alternatives on particular demonstration watersheds in the ABAG study area. The assessment of relative effectiveness provided by these studies can be generalized to other watersheds of similar size, land use and hydrologic composition even through the absolute contaminant reduction predicted may not be transferable. The indication of relative effectiveness can be then extended to obtain county-wide and regional results.

3. Regional Assessment - This analysis was needed to introduce standardization and to remove human judgements, which were so important to the intra-county analyses of existing and projected pollutants loadings and in evaluation of mitigation measures. The regional assessment could not tolerate potential biases introduced through the variance in approaches between counties. The results, such as shown in Figure 16,

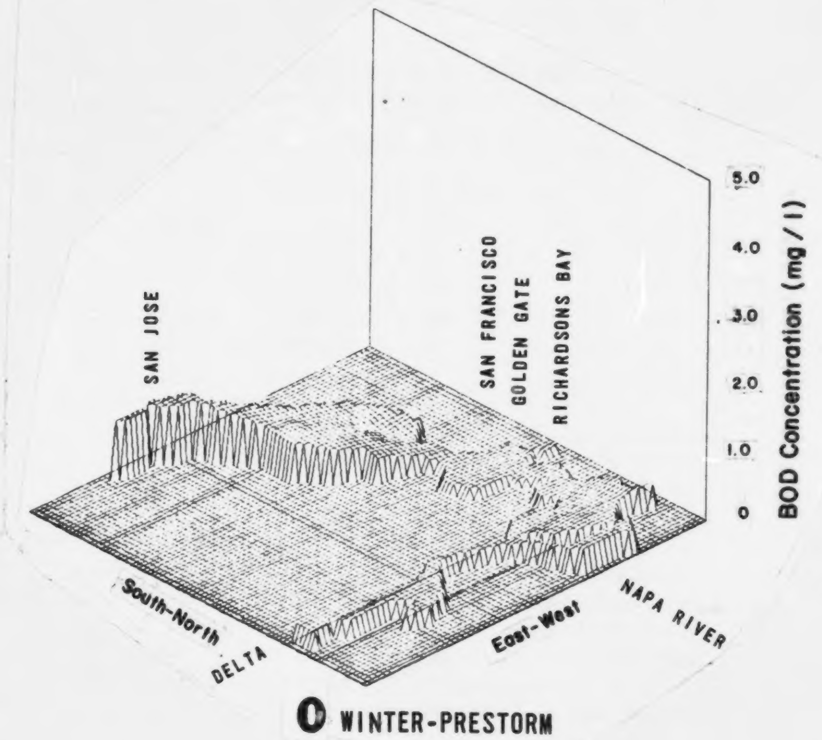

Note: Width of arrows is proportional to annual mass load.
SONOMA
NAPA
SOLANO
Delta winter outflow taken as half estimated annual.
MARIN
CONTRA COSTA
SAN FRANCISCO
ALAMEDA
SAN MATEO
SANTA CLARA
PACIFIC OCEAN
study area boundary
SAN FRANCISCO BAY REGION
ASSOCIATION OF BAY AREA GOVERNMENTS,1978
0
10
20 MILES
0
16
32 KM

REGIONAL LOADING DISTRIBUTION — BOD

Figure 16

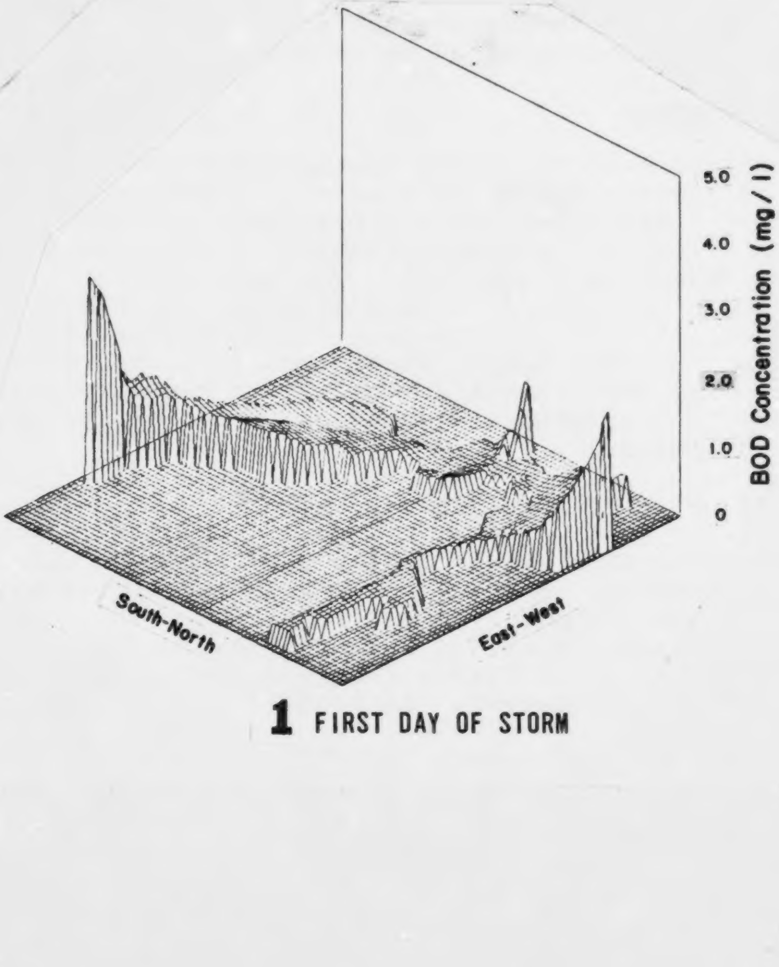
allow the development of regional priorities for plan implementation.

4. Impact on Receiving Waters - ABMAC results from regional assessment were used to evaluate stormwater runoff impact on the San Francisco Bay. Figure 17 shows representative results for a typical, once in 2-year storm. As shown in this three dimensional graphical output, the tendency for concentrations to spike in high discharge, low circulation areas is evident with the greatest buildups experienced at the mouth of the Napa River, Richardsons Bay, and extreme South Bay. The impact zone movement with recovery may also be seen in the diminished but broadened peaks on the second day after the storm.



REPRESENTATIVE STORM IMPACTS ON BAY: BOD

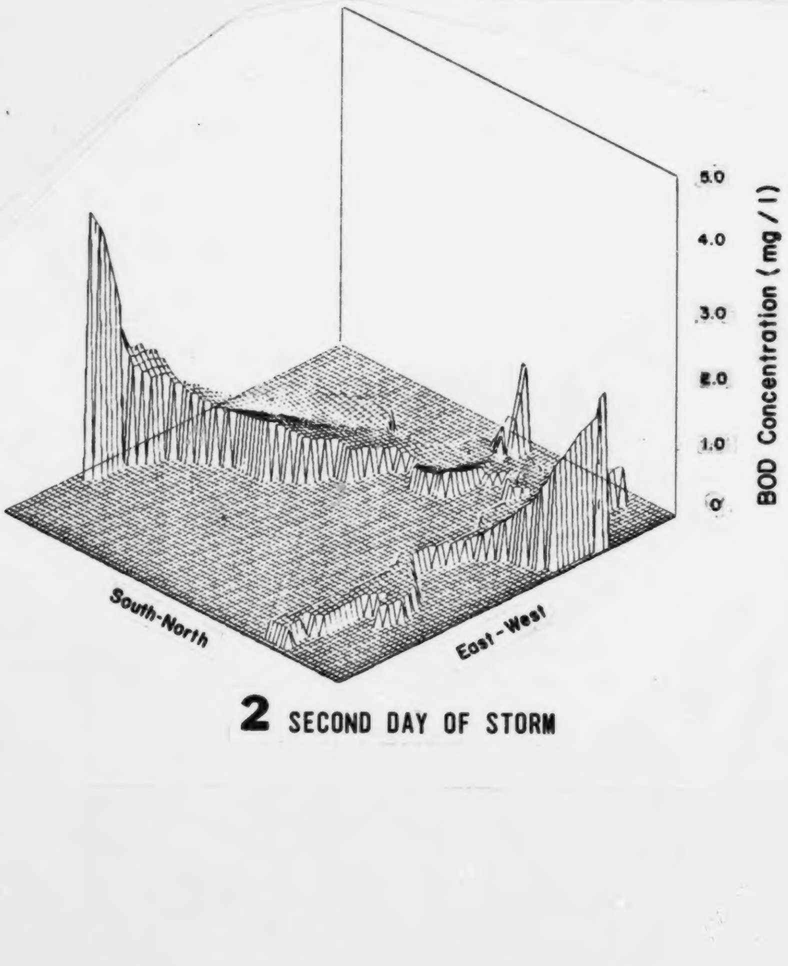
Figure 17



1 FIRST DAY OF STORM

REPRESENTATIVE STORM IMPACTS ON BAY: BOD

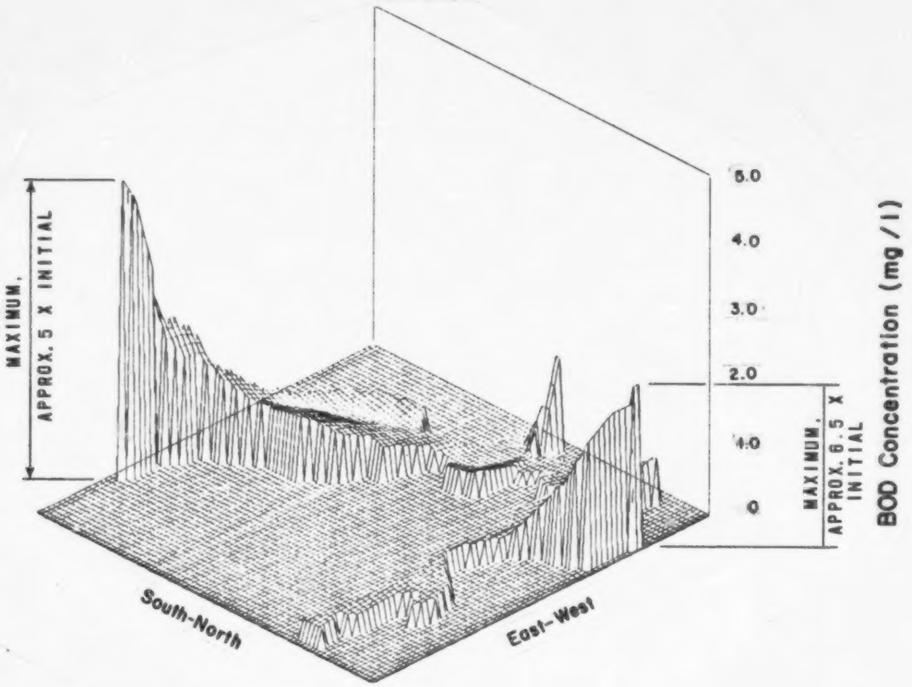
Figure 17 (cont.)



2 SECOND DAY OF STORM

REPRESENTATIVE STORM IMPACTS ON BAY: BOD

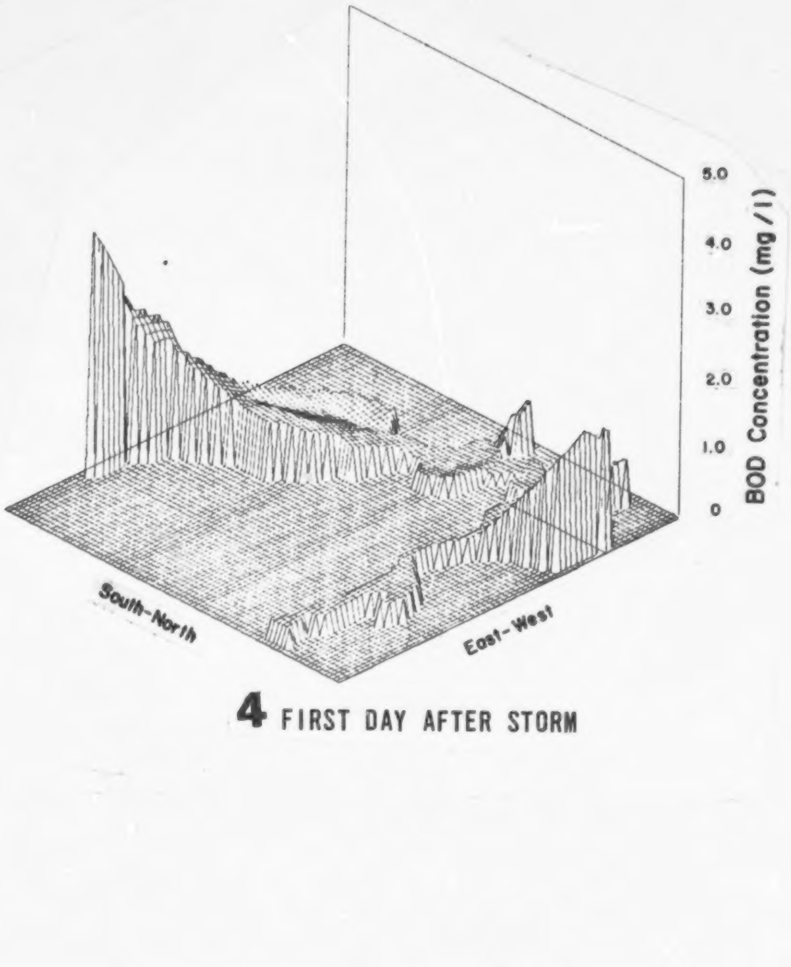
Figure 17 (cont.)



3 THIRD (FINAL) DAY OF STORM

REPRESENTATIVE STORM IMPACTS ON BAY: BOD

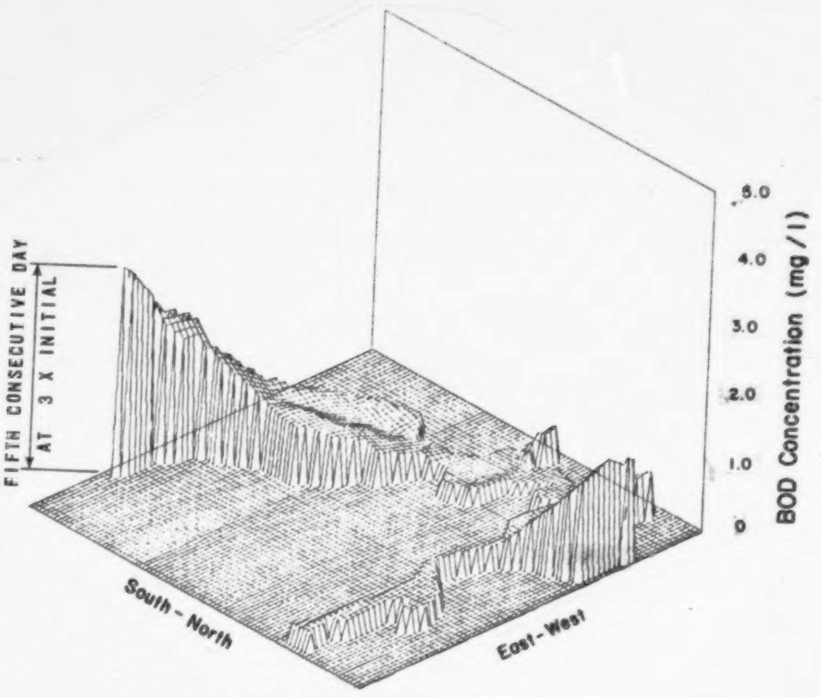
Figure 17 (cont.)



4 FIRST DAY AFTER STORM

REPRESENTATIVE STORM IMPACTS ON BAY: BOD

Figure 17 (cont.)



5 SECOND DAY AFTER STORM

REPRESENTATIVE STORM IMPACTS ON BAY: BOD

Figure 17 (concl.)

SECTION 5

ABMAC MODEL REFINEMENTS

The Need for Model Improvements

The ABMAC Model is based on earlier research work in early 1976, when a simplified methodology for planning and preliminary sizing of stormwater facilities was developed. In its first application to the City of Rochester, New York [7] it has been shown that this methodology was inexpensive to set-up and use, and at the same time it is also adequate for evaluating a variety of system configurations with reasonable accuracy and flexibility.

In late 1976, this methodology was adopted for ABAG surface runoff water quality analysis as discussed in Section 4. At that time the model was still relatively new and untested. The main motivation for its application stemmed from the following:

- time constraints, budgetary limitations and data availability for model calibration did not justify the use of a more sophisticated model, and
- the assumption was made that since the model is based on the simple rational approach, local planners and engineers would rapidly become familiar with the model and its applications and would therefore be inclined to use the model for continuing planning activities.

The two-year experience of model application by ABAG was an overall success in attaining the stated objectives of surface runoff analysis. However, it revealed a number of user-oriented deficiencies, which called for model refinements prior to further application in a continuous 208 planning effort.

In an attempt to systematically assess the desired modifications and priorities for such a future application, a questionnaire was sent to all the participating counties. The questionnaire addressed four major issues:

- technical background of respondent
- experience with the ABMAC model
- utility of ABMAC Model
- suggested modifications

The evaluation of responses revealed that all the respondent had good familiarity with the model, they had the in-house ability to use the model, and intended to make further application of the model in the Continuing Planning Process of the 208 Program. The main problem areas identified were:

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

- o user-oriented conveniences for model application.
- o the limited model verification so far

In the discussion of user oriented conveniences it was stressed that, despite its simplicity, model application was not as simple as initially anticipated. For example updating and modification of model inputs for various planning alternatives becomes cumbersome, time consuming and prone to errors when done for a large number of watersheds. As to the limited model application it was recognized that it was affected to a large extent by the drought during the 1976/77 rainy season. A general consensus in this regard was that if the model can be shown to have accuracy within reasonable limits, then it can be very useful.

The Introduced Refinements

The following general model refinements have been introduced subsequent to its initial application in ABAG's surface runoff water quality analysis. The resulting ABMAC model has been described in Section 3 of this report and in Part - II Users Manual.

- o Modifications of Model Inputs - the inputs have been streamlined with many user oriented conveniences for different application situations.
- o Check of Input Data - cross reference of all the input data is now possible to allow quick detection of any inconsistencies or errors in the input string.
- o Update of Input Data - the model modifications introduced facilitate updating of a given segment of the input information.

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

SECTION 6

MODEL CALIBRATION AND TESTING

The original data base used in calibration of the model for ABAG Surface Runoff Modeling Study was deficient because no observable flows could be recorded in open areas during that year due to the drought. Consequently, a sampling program was structured to fill in the missing link in the available water quality data for calibration and testing of the refined ABMAC. The resulting data collection stations and data analysis methods are described in this section. Also presented are calibration procedures model sensitivity and the recommended open space input variables for the tested watersheds.

MONITORING STATIONS

6-1/2"

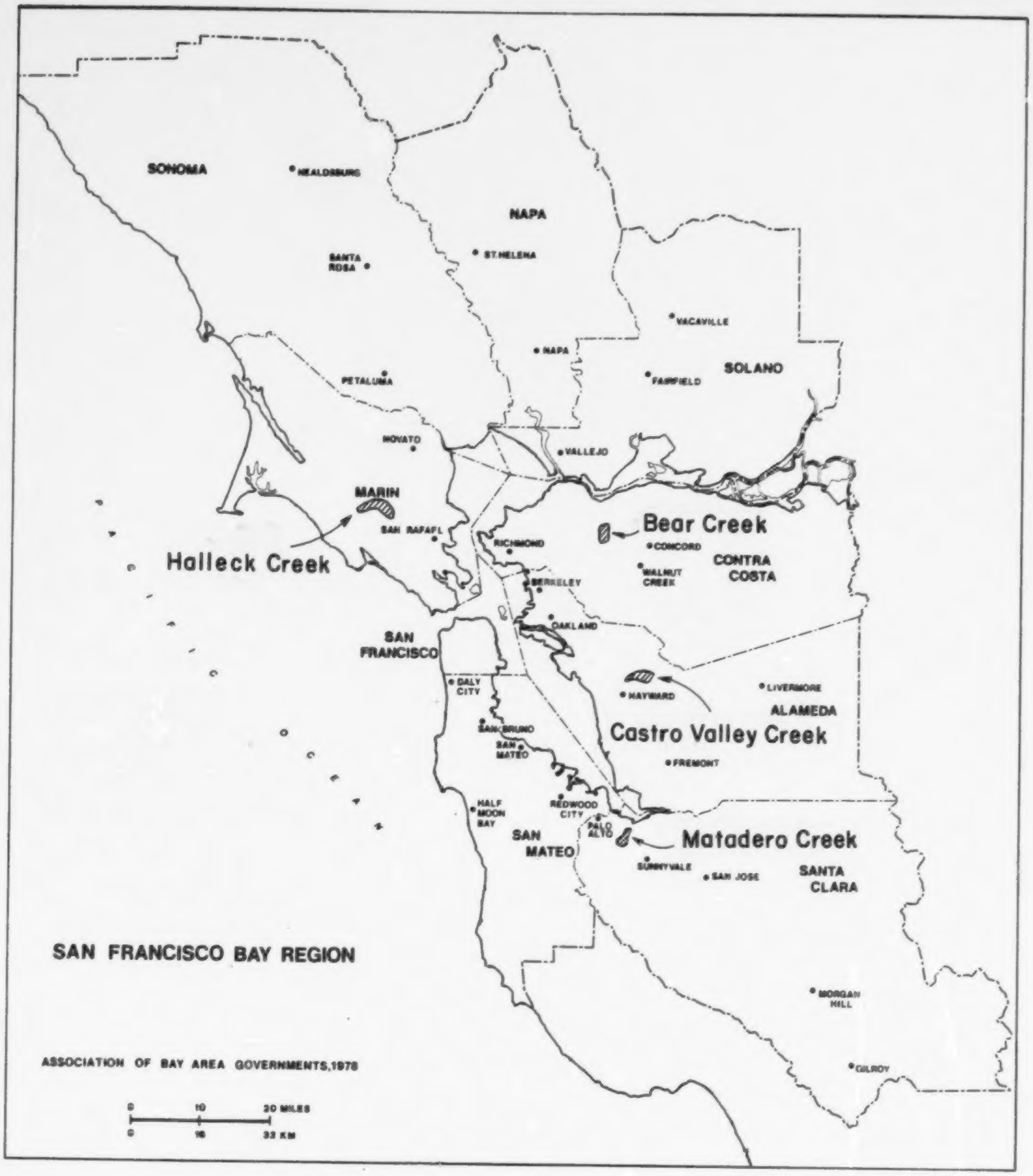
Four open space areas were chosen as sites to sample runoff quality and quantity. The stations are: Halleck Creek, Marin County; Bear Creek, Contra Costa County; Matadero Creek, Santa Clara County and Castro Valley Creek (Seaview Station), Alameda County. All four stations are located within the ABAG Surface Runoff Water Quality Study Area, (see Figure 18). Table 17 provides general description of the samples sites. The contributing watersheds are shown in Figure 19.

The pollutants measured at each station were BOD_5, suspended solids, volatile SS, total nitrogen as N and total phosphorus as P. Flow measurements were taken at all stations. The total flow during the measured storm duration was calculated. Since the ABMAC model calculates values on a 24-hour basis rather than storm by storm, the calculated flows were also adjusted to a 24-hour equivalent. A storm which was sampled for 20 hours would have 4 hours of additional flow added at a low flow condition. The low flow condition was an attempt to approximate the delayed direct runoff contribution represented by base flow. Pollutant concentrations were flow weighted to estimate pounds of pollutant coming from the watersheds. A 24-hour adjustment was made to the pollutant loads similar to that executed on flow values. Pollutant concentrations were compared with those reported in the ABAG Surface Runoff Modeling Study [2].

The data collection procedures used at the four locations differed since four different agencies performed the data collection, tabulation, and summarization. Flow and pollutant concentrations were taken hourly at Matadero Creek; however, Halleck Creek data was recorded from 2 to 12 hours apart. Bear Creek was sampled in 1 to 16 hour intervals. The data for Seaview was presented as total storm flow and total pounds of pollutants, without specifying the duration of storm. Consequently,

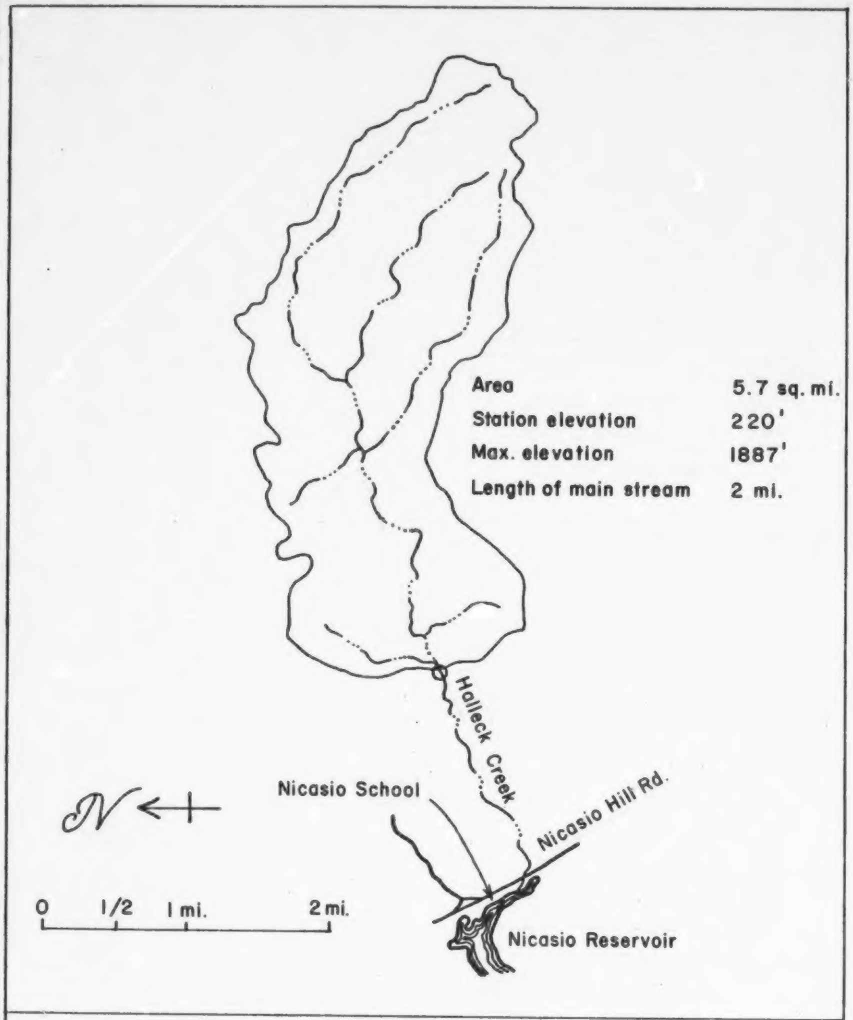
BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)


SONOMA
HEALDSBURG
NAPA
ST. HELENA
SANTA ROSA
VACAVILLE
NAPA
SOLANO
FAIRFIELD
PETALUMA
NOVATO
VALLEJO
MARIN
SAN RAFAEL
Bear Creek
CONCORD
CONTRA COSTA
WALNUT CREEK
Halleck Creek
RICHMOND
BERKELEY
OAKLAND
SAN FRANCISCO
DALY CITY
HAYWARD
LIVERMORE
ALAMEDA
Castro Valley Creek
SAN BRUNO
SAN MATEO
FREMONT
HALF MOON BAY
REDWOOD CITY
PALO ALTO
Matadero Creek
SAN MATEO
SUNNYVALE
SAN JOSE
SANTA CLARA
SAN FRANCISCO BAY REGION
MORGAN HILL
ASSOCIATION OF BAY AREA GOVERNMENTS,1978
GILROY
0 10 20 MILES
0 16 32 KM

WATER QUALITY SAMPLING PROGRAM
FOR ABMAC MODEL CALIBRATION

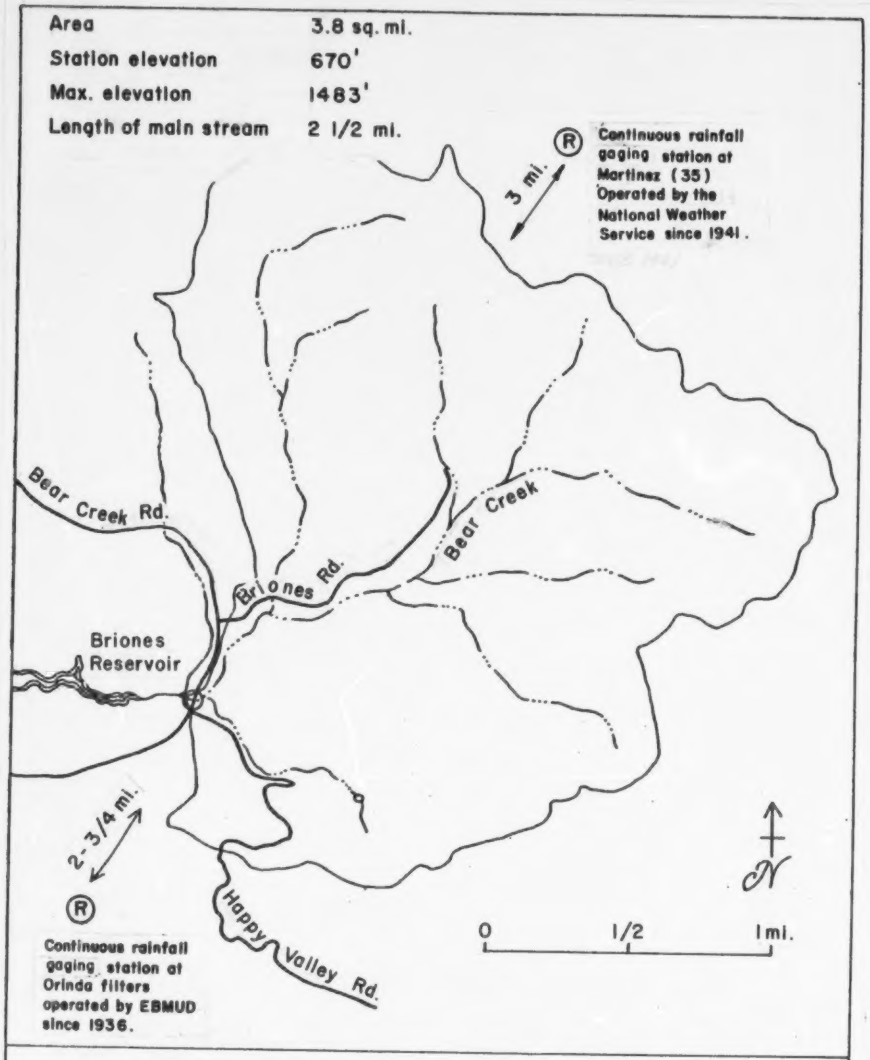
Figure 18


Area 5.7 sq. mi.
Station elevation 220'
Max. elevation 1887'
Length of main stream 2 mi.
Halleck Creek
Nicasio School
Nicasio Hill Rd.
N
0
1/2
1 mi.
2 mi.
Nicasio Reservoir

Halleck Creek at " Three Culvert " Bridge

SAMPLING WATERSHEDS
FOR ABMAC CALIBRATION

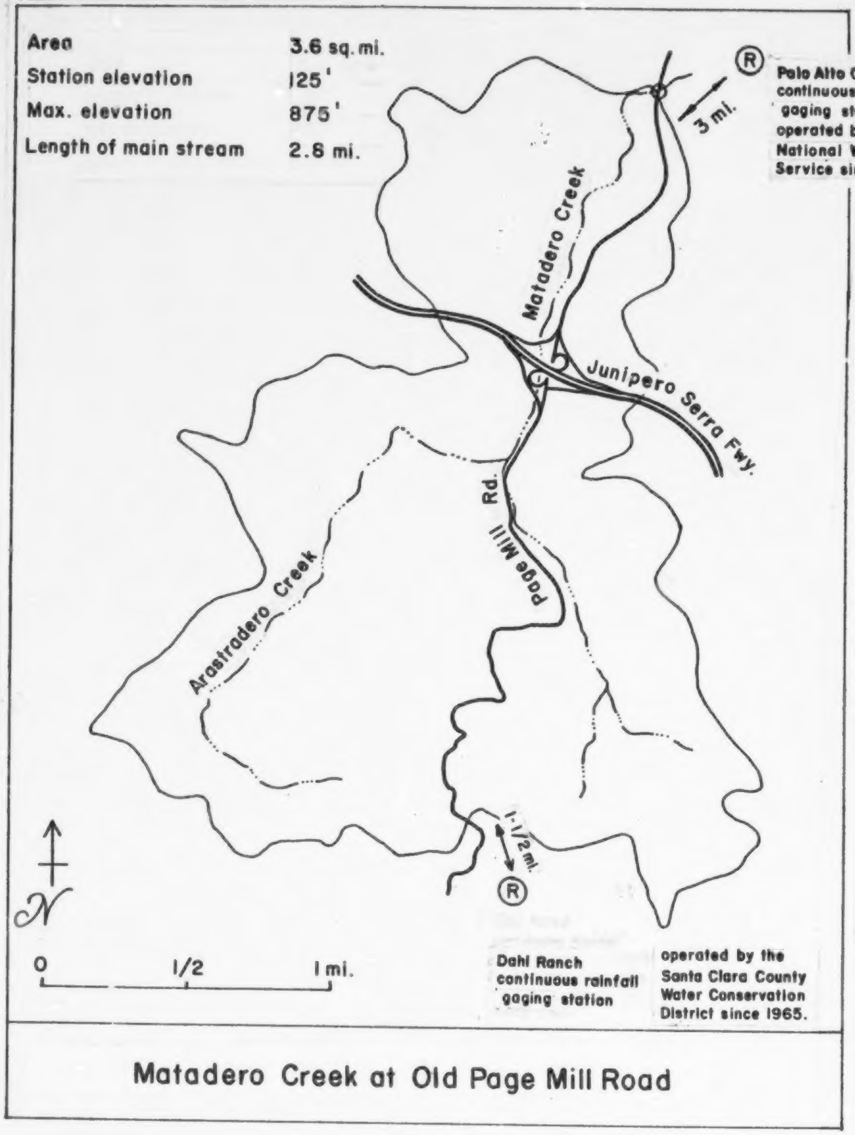
Figure 19


Area 3.8 sq. mi.
Station elevation 670'
Max. elevation 1483'
Length of main stream 2 1/2 mi.
Ⓡ Continuous rainfall gaging station at Martinez (35) Operated by the National Weather Service since 1941.
3 mi.
Bear Creek Rd.
Bear Creek
Briones Rd.
Briones Reservoir
2-3/4 mi.
Ⓡ Continuous rainfall gaging station at Orinda filters operated by EBMUD since 1936.
Happy Valley Rd.
N
0
1/2
1 mi.

Bear Creek below Bear Creek Road

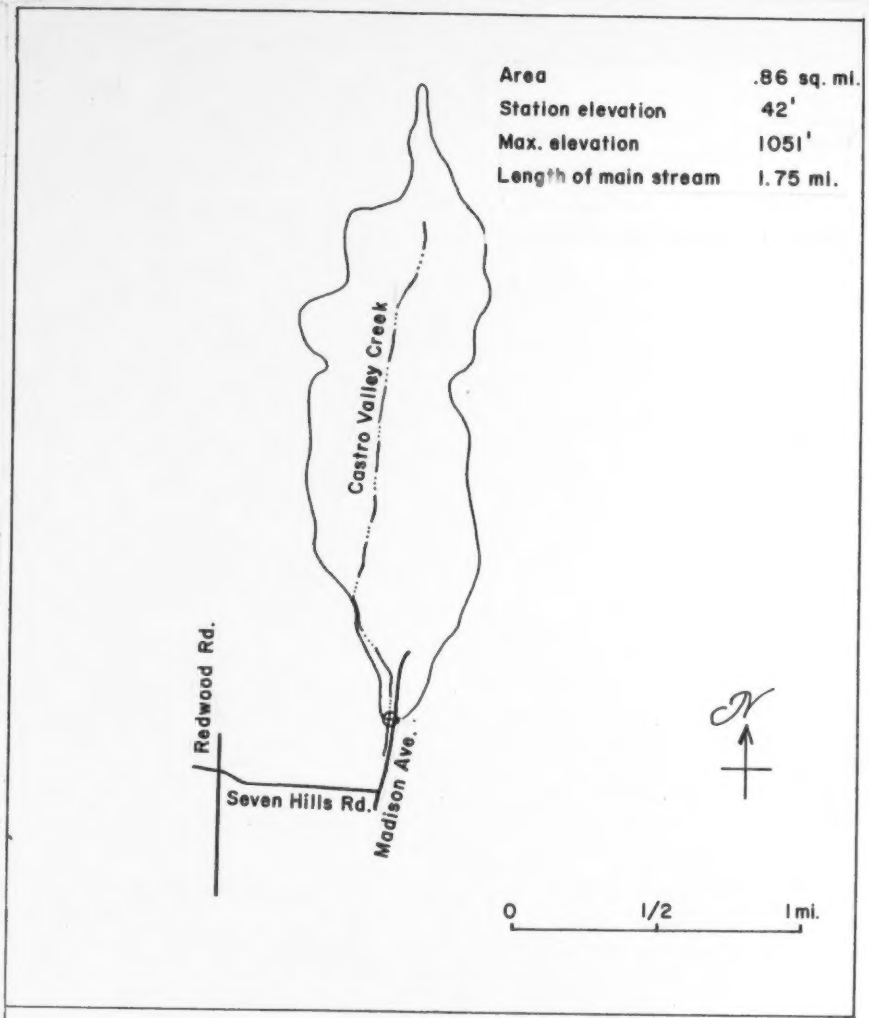
SAMPLING WATERSHEDS FOR ABMAC CALIBRATION

Figure 19 (cont.)


Area 3.6 sq. mi.
Station elevation 125'
Max. elevation 875'
Length of main stream 2.8 mi.
Palo Alto City Hall continuous rainfall gaging station operated by National Weather Service since 1953.
3 mi.
Matadero Creek
Junipero Serra Fwy.
Page Mill Rd.
Arastradero Creek
1-1/2 mi.
N
0
1/2
1 mi.
Dahl Ranch continuous rainfall gaging station
operated by the Santa Clara County Water Conservation District since 1965.
Matadero Creek at Old Page Mill Road

SAMPLING WATERSHEDS FOR ABMAC CALIBRATION

Figure 19 (cont.)


Area .86 sq. mi.
Station elevation 42'
Max. elevation 1051'
Length of main stream 1.75 mi.
Castro Valley Creek
Redwood Rd.
Seven Hills Rd.
Madison Ave.
N
0
1/2
1 mi.

Castro Valley Creek above Seven Hills Road
(Seaview)

SAMPLING WATERSHEDS FOR ABMAC CALIBRATION

Figure 19 (concl.)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

TABLE 17. SAMPLING SITES CHARACTERISTICS

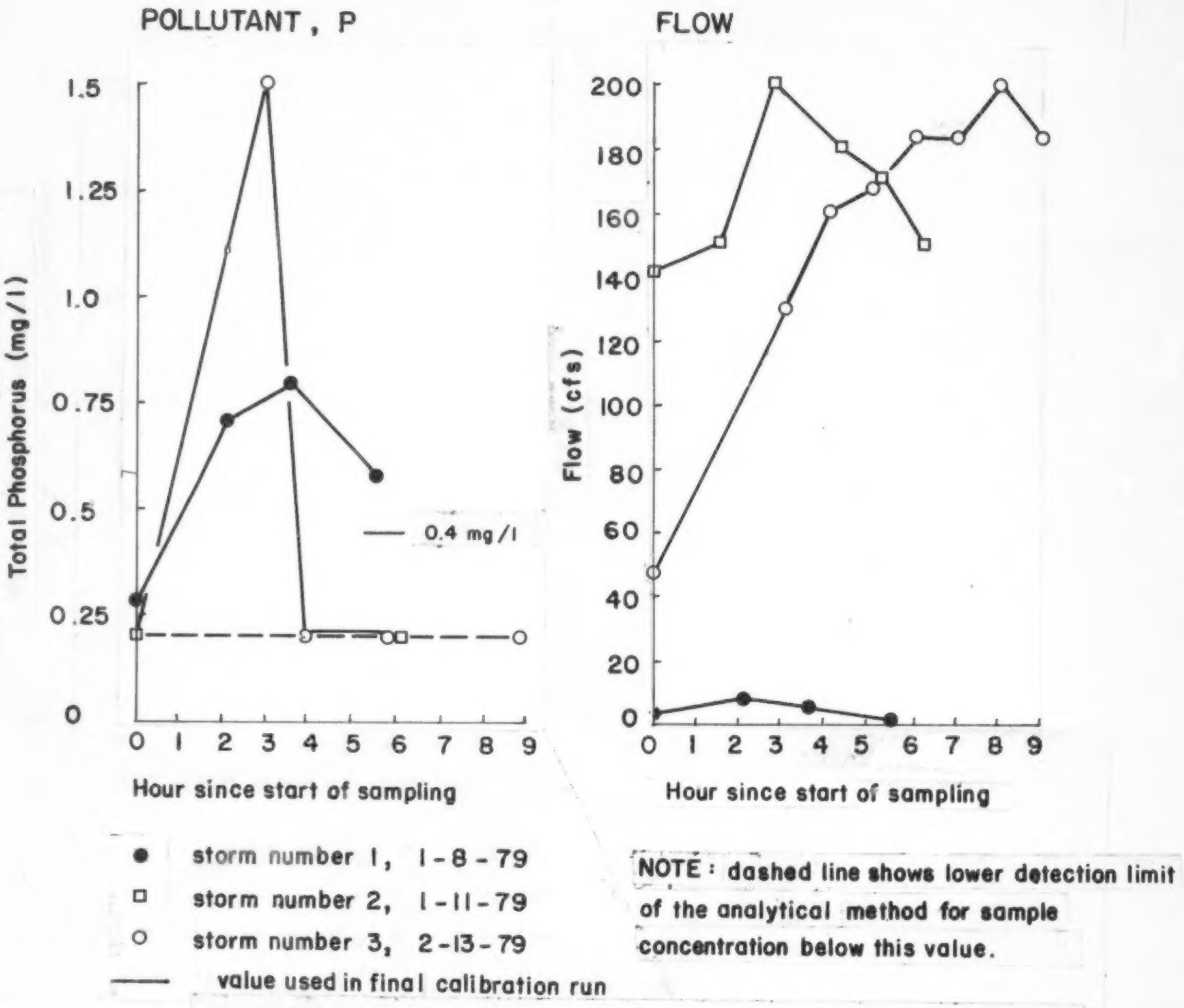
WATERSHED NAME	AREA (sq. mi.)	ELEVATION (ft) above MSL		SAMPLING SITE CHARACTERISTICS
		Sampling Site	Maximum	
1. Halleck Creek at the Three Culvert Bridge	5.69	220	1887	Old bridge with 3 circular 8 ft. dia. culverts. Staff gage. Water quality sampling from the bridge.
2. Bear Creek below Bear Creek Road	3.82	670	1483	Trail crossing bridge consisting of 3 corrugated metal pipes. Staff gage, flow velocity measurements with current meter. Sampling from the bridge.
3. Castro Valley Creek above Seven Hills Road (Seaview Station)	0.86	425	1051	New water stage recorder installed by USGS, automatic water quality sampler.
4. Matadero Creek at the Old Page Mill Road	3.64	125	875	Rect. 12x8 ft. concrete channel. Staff gage, flow velocity at various stages for rating curve development. Water quality sampling from bridge.

Source: [6].

Seaview was the only station not adjusted to a 24-hour equivalent. The runoff quantity and quality data for Matadero Creek, Bear Creek, and Halleck Creek are shown in Figures 20 to 22. There are six graphs for each of the stations, one for flow and one for each of the five pollutants (BOD_5, SS, VSS, N and P). Also included on the graphs for comparison is the final value used as input in calibration.

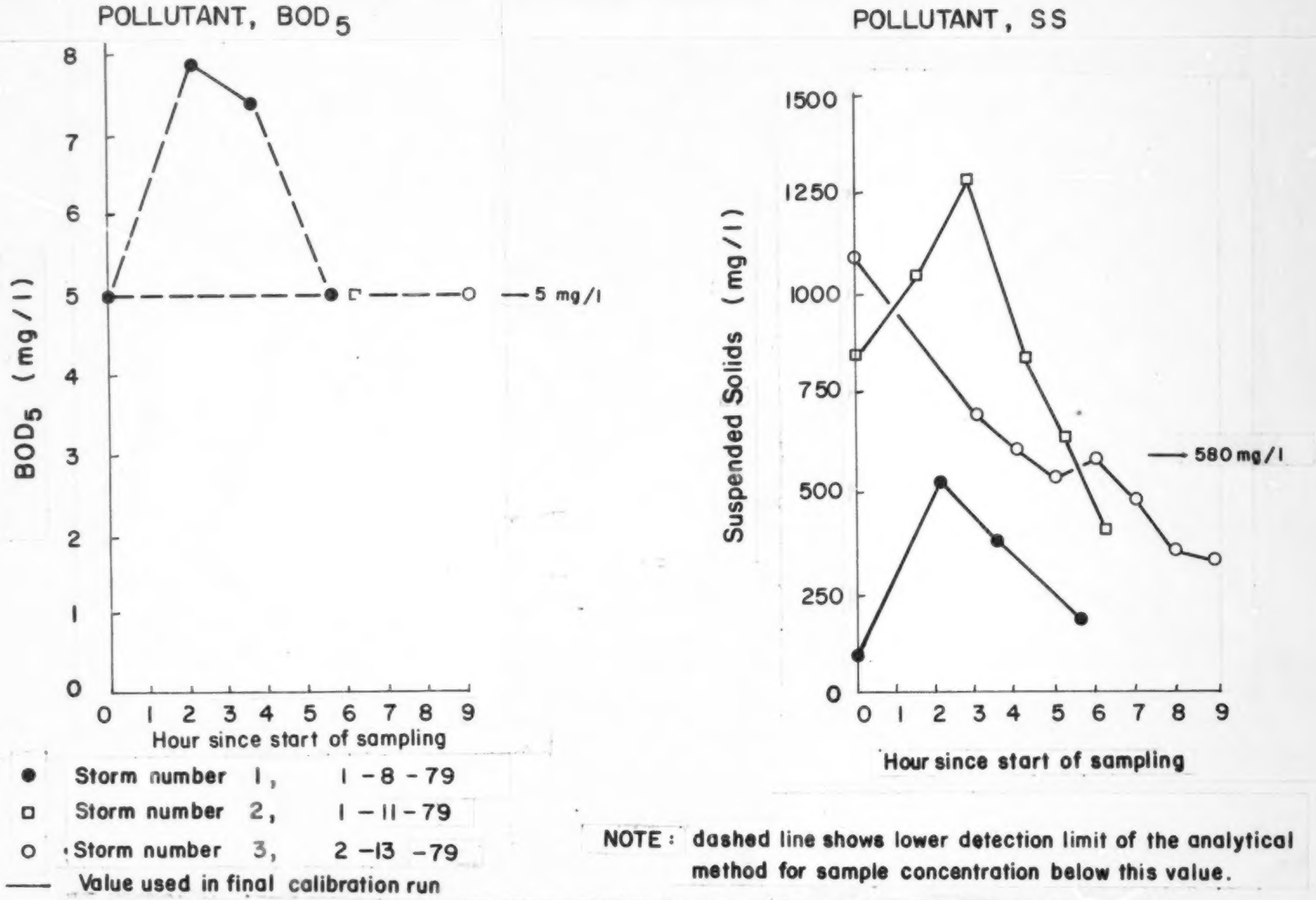
6-1/2"
BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)



WATER QUALITY DATA FOR HALLECK CREEK

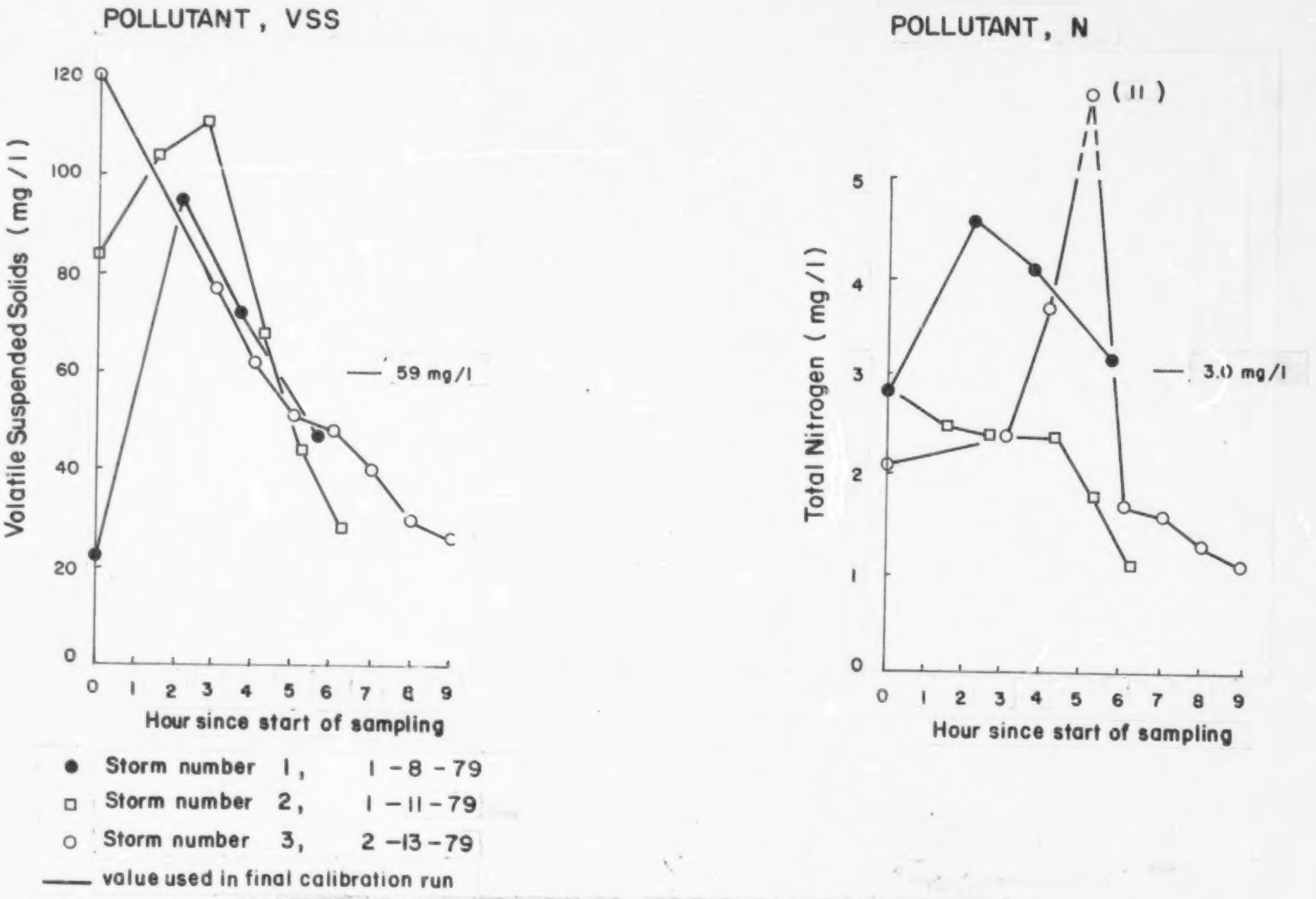
Figure 20



NOTE: dashed line shows lower detection limit of the analytical method for sample concentration below this value.

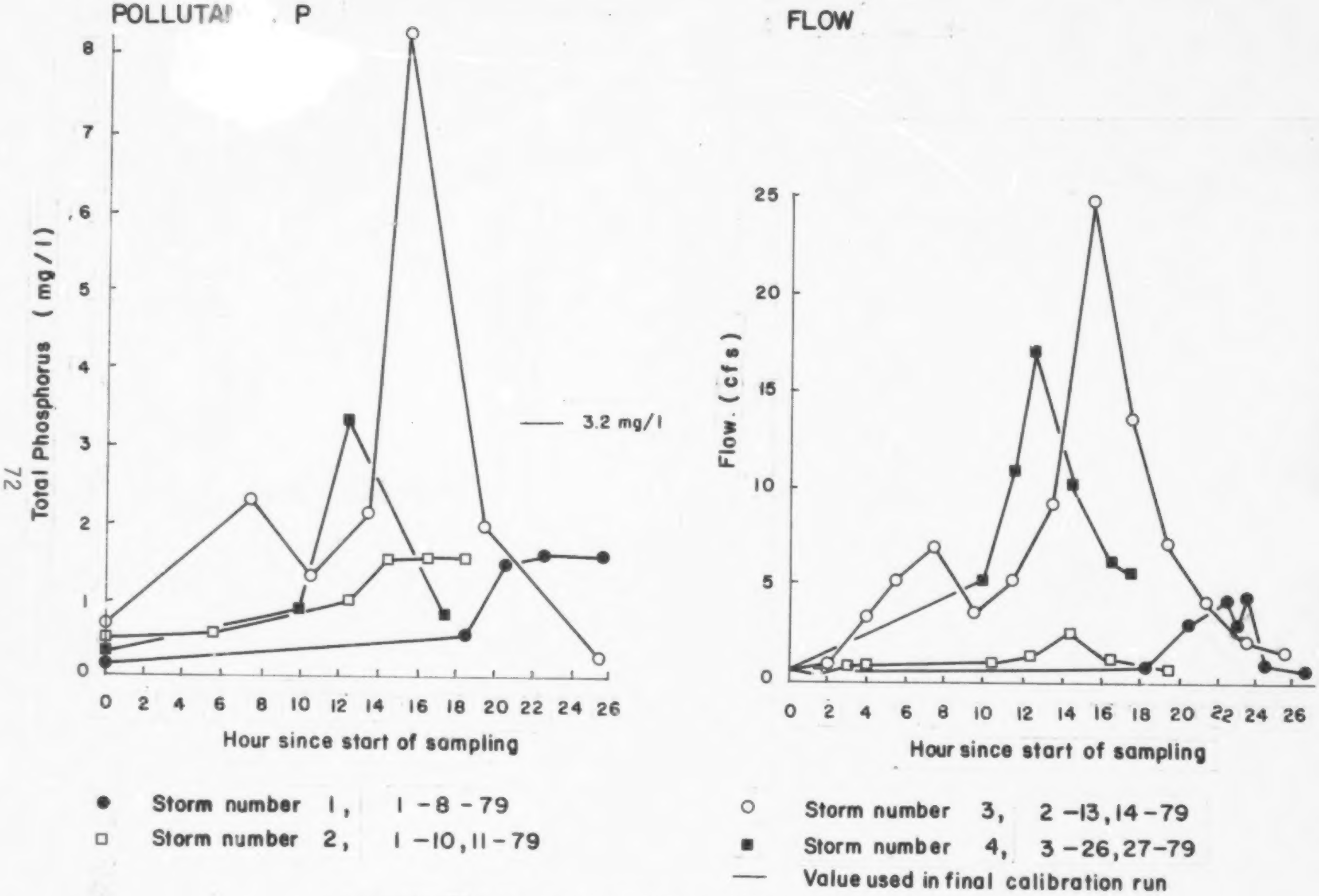
WATER QUALITY DATA FOR HALLECK CREEK

Figure 20 (cont.)



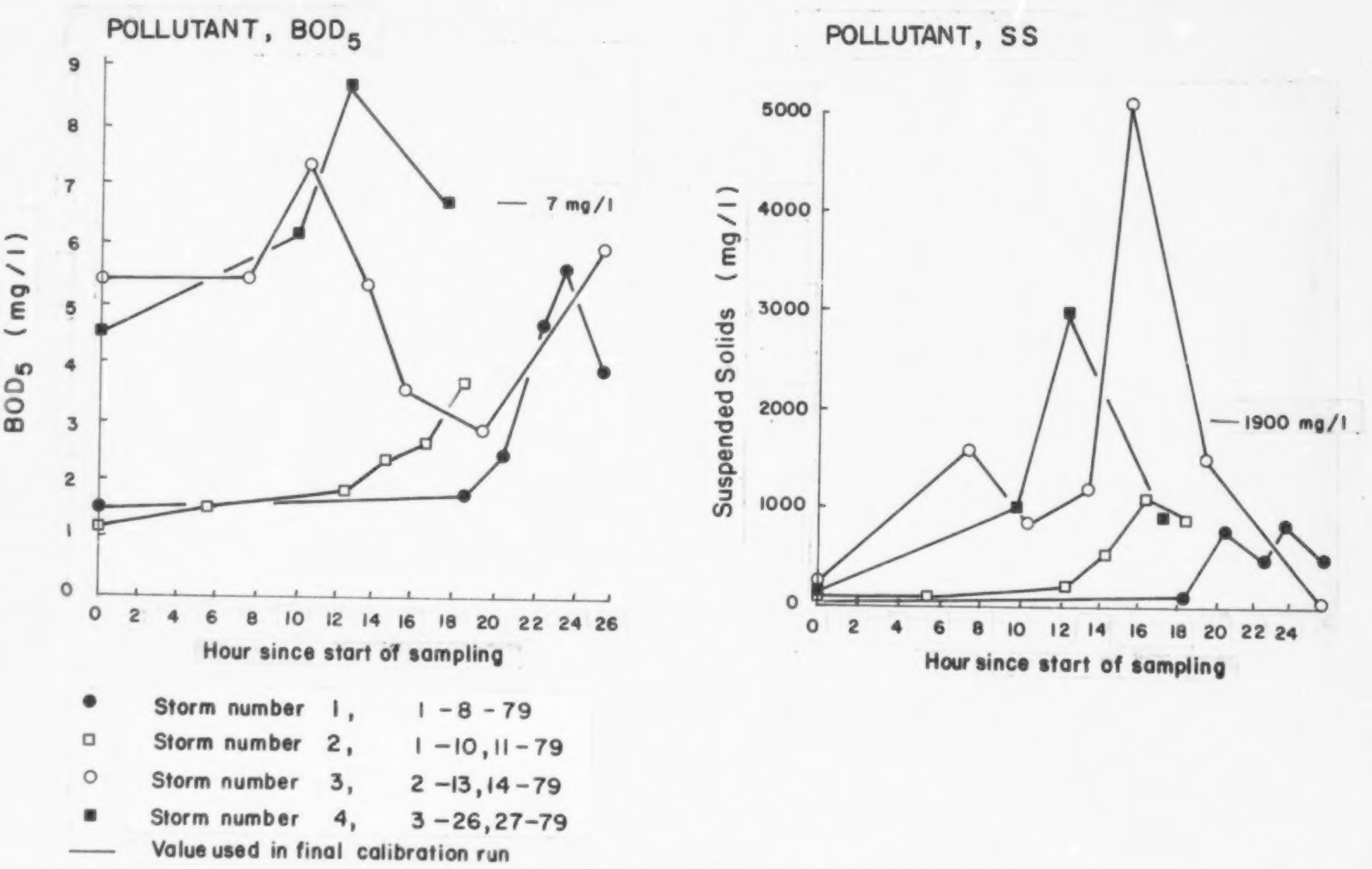
WATER QUALITY DATA FOR HALLECK CREEK

Figure 20 (concl.)



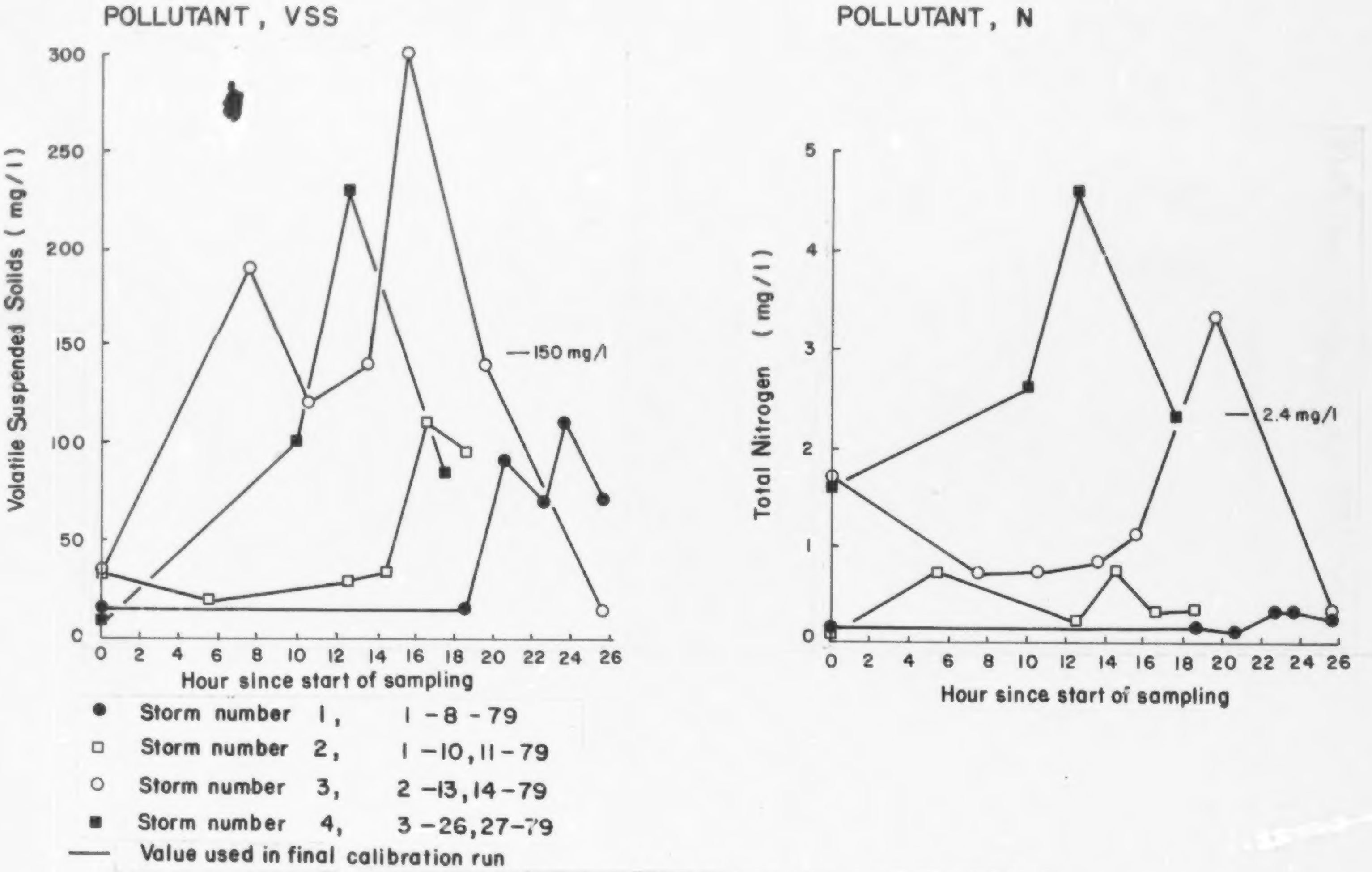
WATER QUALITY DATA FOR BEAR CREEK

Figure 21



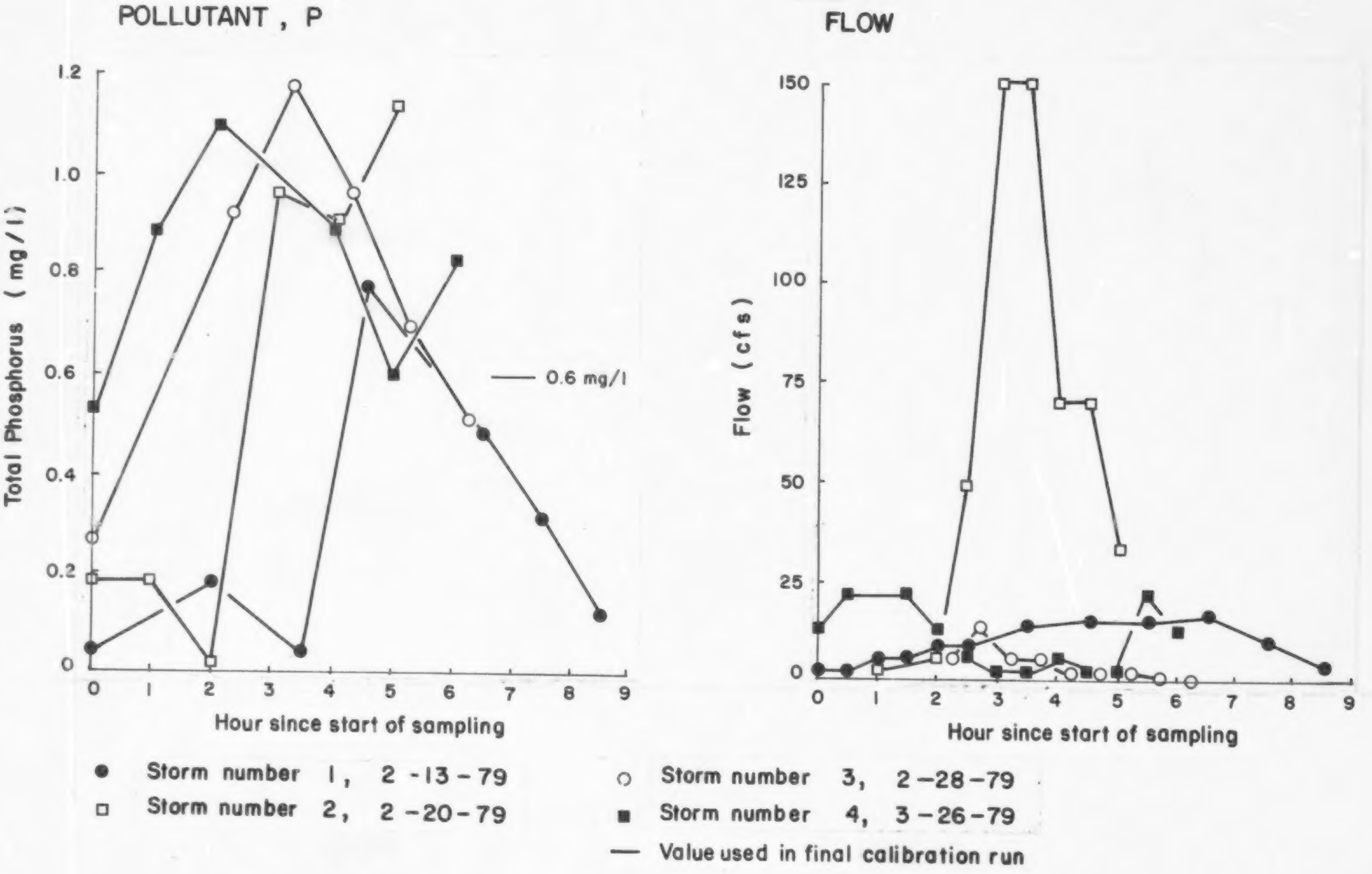
WATER QUALITY DATA FOR BEAR CREEK

Figure 21 (cont.)



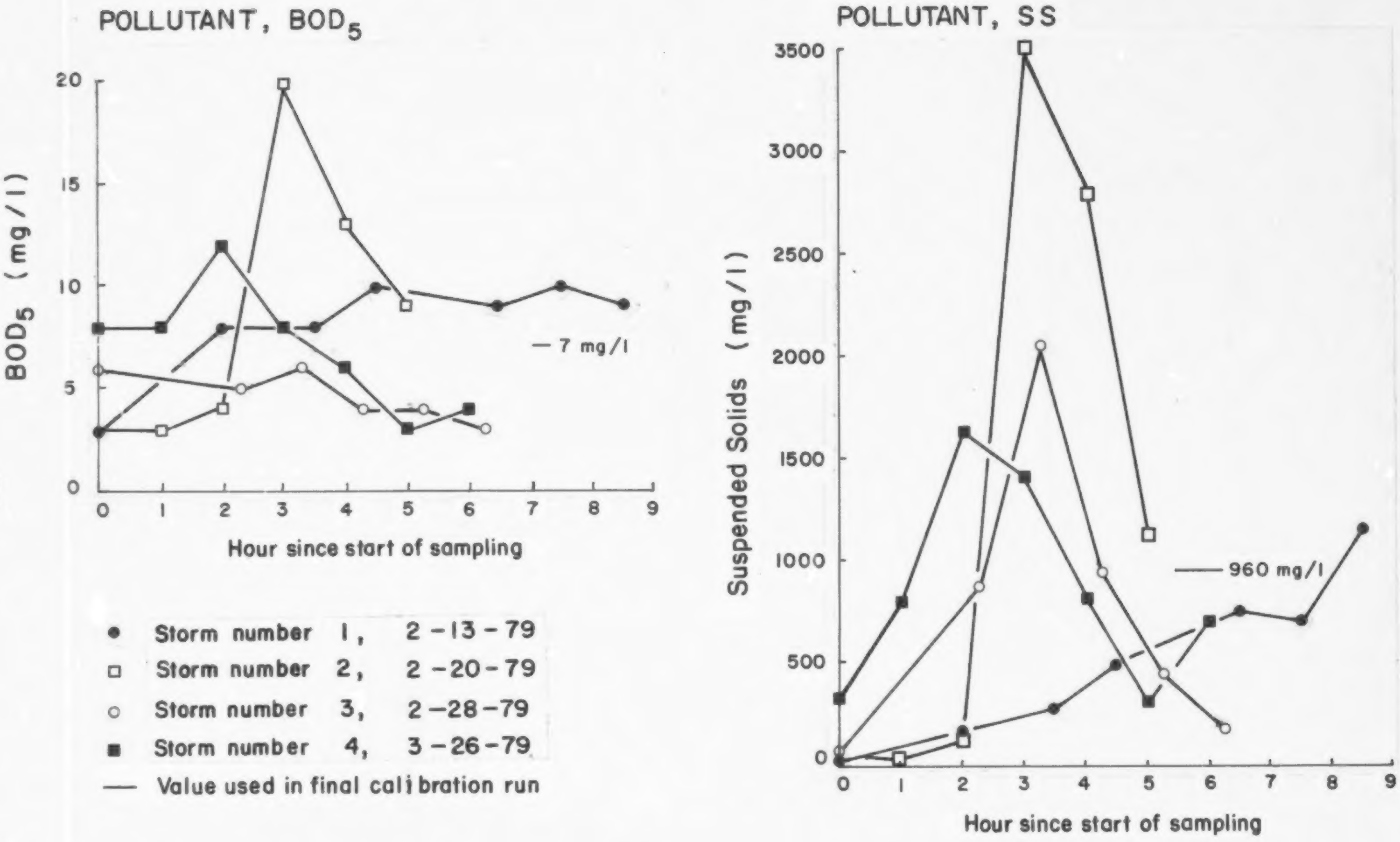
WATER QUALITY DATA FOR BEAR CREEK

Figure 21 (concl.)



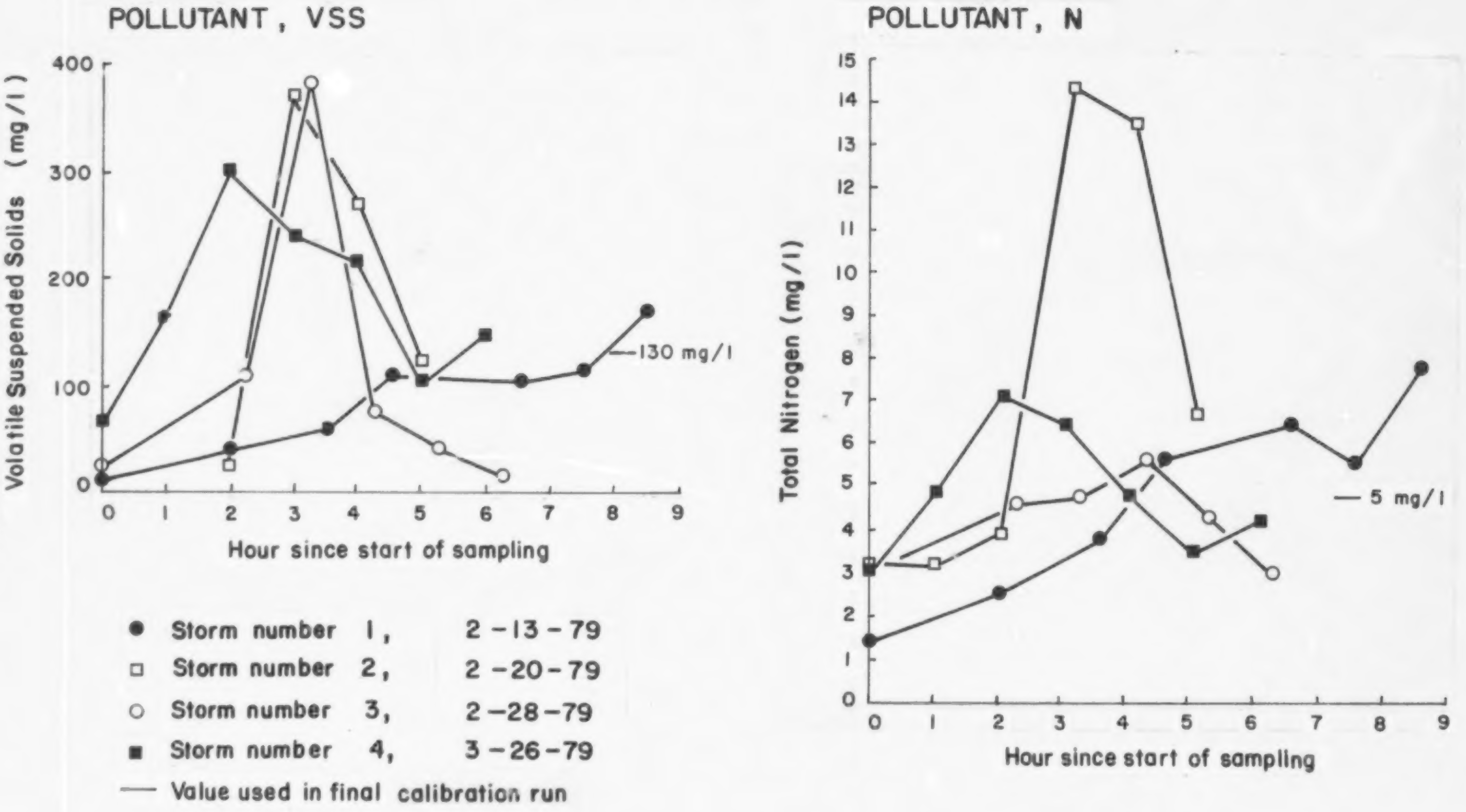
WATER QUALITY DATA FOR UPPER MATADERO CREEK

Figure 22



WATER QUALITY DATA FOR UPPER MATADERO CREEK

Figure 22 (cont.)



WATER QUALITY DATA FOR UPPER MATADERO CREEK

Figure 22 (concl.)

MODEL CALIBRATION

General Considerations

ABMAC is a broad scale model. It is designed to operate on many years of rainfall data to give yearly and long term seasonal relationships between alternatives and watersheds. To be cost effective and yet still operate on large rainfall input files, the algorithm is fairly simple. Although the calculations are made using a daily time step, ABMAC is really a yearly model.

The yearly concept is especially applicable to open space watersheds. Over a rain season, early storms demonstrate very low runoff coefficients as the soil has a high moisture requirement. At the end of a season, runoff is higher because the moisture debt has been satsified. A single input runoff coefficient as required by this model must represent a yearly average. Examination of runoff coefficients from individual storms would be expected to show a high variability as compared to the yearly value.

Another important concept regarding use of ABMAC on a yearly basis involves the relation between immediate and delayed direct runoff. When determining the total stormwater pollutant load contributed by a watershed there are two major components. The first, immediate direct surface runoff, occurs within a few days time and was measured at the four stations during this study. The second, delayed direct runoff, may occur for months after a storm, and was not measured as part of this study. Typically, the immediate surface runoff has high pollutant concentrations; the delayed runoff usually has low pollutant concentrations. However, the total volume of the delayed runoff over a rain season, even at a low pollutant concentration, may represent a large portion of the total pollutant load from that watershed.

One last item to note is that the 1978-79 season had a rainfall 18 percent lower than the normal annual amount for the San Francisco Bay Area. By the end of January, less than 40 percent of the rainfall had fallen rather than the normal 60 percent of precipitation occurring by that time. An unusually wet February brought the amount of rain to 70 percent of normal rather than the usual 75 percent by the end of February.

Model Inputs for Calibration

The major input parameters to the ABMAC Model are rainfall data, pollutant concentrations, acreages, and runoff coefficients. These input data were obtained from the following sources:

Rainfall - Data were obtained from local rain gages. Marin Municipal Water District's Nicasio Reservoir gage was used for Halleck Creek. East Bay Municipal Utility District's San Pablo Reservoir gage was used for Bear Creek; Santa Clara Flood Control District's Dahl Ranch gage was used for Matadero Creek; United States Geological Survey's Sydney School and Proctor School gages and the Castro Valley Fire Station gage were used for the Castro Valley - Seaview Station. The data was used directly except for Castro Valley where three gages were combined using a Thiessen Polygon analysis.

Pollutant Concentrations - Inputs were selected for each watershed based on the quality monitoring data. Flow weighted concentrations for each storm were determined and a typical value, close to the average of the flow weighted values, was chosen as input to the model. The concentration ranges and the selected input value for the initial computer trial are listed in Table 18.

TABLE 18. TYPICAL POLLUTANT CONCENTRATIONS
(24-hr basis, i.e., including base flow)
(mg/l)

–	BOD	SS	VSS	N	P
Matadero Creek, Santa Clara County					
Range	5.4-12.7	368-2,202	67-232	4-10.8	0.30-0.76
Average	7.8	965	134	5.06	0.58
Chosen	7	960	130	5.0	0.60
Bear Creek, Contra Costa County					
Range	3.1-7.4	448-2,075	55-164	0.19-3.5	1.00-3.27
Average	5.14	1,293	133	1.64	2.36
Chosen	5	1,300	130	1.60	2.30
Halleck Creek, Marin County					
Range	<5-5.9	222-924	46-77	2.32-3.41	<0.2-0.46
Average	5.3	582	58.7	2.97	0.35
Chosen	5	580	59	3.0	0.40
Seaview, Alameda County[a]					
Range	--[b]	228-1,010	26-138	1.3-8.1	0.27-1.9
Average	--	603	88	4.86	0.77
Chosen	--	600	88	4.9	0.8

a. Storm only. No 24-hr basis available.

b. No BOD measurements made.

Source: [6].

Land Use Data - Acreages for the watersheds were known. The Halleck Creek watershed, with the exception of just a few farms, is a watershed in its natural state with the upper portion of the watershed steeply sloping and having rolling hills in its lower portion. It is covered by a sparsely wooded deciduous forest. The Bear Creek watershed is entirely located within the Briones Regional Park. It is undeveloped land mostly owned by the East Bay Regional Park District. It is characterized by steeply sloping terrain with sparsely wooded slopes of mostly deciduous trees. There are several houses just upstream from the gauging station. The rest of the watershed is undeveloped. The Castro Valley Creek watershed (Seaview Station) is characterized by undeveloped steep hills covered with grass vegatation only. The Matadero Creek watershed is a hilly, lightly developed watershed. It contains a number of roads, a country club and quite a few houses scattered over a large area.

Runoff Coefficient - The runoff coefficient was also analyzed on a storm by storm basis for each watershed to derive approximate values. A representative runoff coefficient, close to the average value, was chosen as input to the model. Table 19 lists the range of runoff coefficients chosen for input to the first calibration run.

TABLE 19. ESTIMATED RUNOFF COEFFICIENTS

	Matadero Creek	Bear Creek	Halleck Creek	Seaview
ASRR[a]	0.12	0.11-0.20	0.26-0.30	0.15-0.17
Range from data, 24 hr	0.046-0.393	0.014-0.45	0.022-0.60	0.028-1.07
Average value	0.06	0.05	0.26	0.07
Chosen typical value	0.07	0.06	0.26	0.09

a. Values reported in ABAG Surface Runoff Report

Source: [6].

The various input parameters were then assembled into the input data deck, shown in Table 20. Since rain data was different for each subarea, the basic nonconsolidated format was chosen.

Calibration Runs

Calibration was completed in three runs. As a preparation to the calibration runs, model generated flow and pollutant loads were compared to measured values for each storm of each watershed. The simulated measured ratio was then computed for each storm as well as for the summation of storms for a single watershed. Tables 21 through 24 contain the calculated and measured values and ratios observed. Also shown in these tables are the arithmetic average of the ratios from each storm for each watershed. The ratio developed from the summation of flow and loads from each storm was given the most importance in determining the "closeness" of the fit of simulated and recorded data. Since this model functions by smoothing out irregularities of single storms into average values, it was felt the model should be calibrated

TABLE 20. ABMAC VERIFICATION INPUT DECK - FIRST CALIBRATION RUN

```
 4   1     ABAG / M&E
01MATADERO CREEK                                                        71978
020PEN                  0.7     7.0     960.    130.    5.0     0.6
03
04
05
06
07
08
09SANTA CLARA COUNTY    2330.
10
      1978        5                             1.
0909  801112  301113  101119  401120 1401121  401122  201201  201202  101217  40
1221  600104  100105  100107  300108 1900109  100110  700111 2400114 2900115  50
0117  200130  400201  100213 3000214  200215  300216  200218  600219  400220  80
0221  700222 1600223  200225  400228  600302  100304  100312  100313  100315  30
0316  400318  200326  900327 2200328  60
9999999999999999999
01BEAR CREEK
020PEN                  0.6     5.0     1300.   130.    1.6     2.3
03
04
05
06
07
08
09CONTRA COSTA CO.      2440.
10
      1978        5                             1.
0911  821113  281114  031119  461120  531121  291122  281123  061201  161217  20
1218  820104  090105  040106  020108  050109 1630110  030111 2220112  510113  05
0114 1000115 1360116  340117  010118  200130  070131  340201  030202  010213  92
0214 1350216  360217  290218  290219  270220  660221  500222 1950224  120226  32
0301  790303  100308  010310  010316  670317  080321  020327 1420328  40
9999999999999999999999999
01CASTRO VALLEY
020PEN                  0.09    5.0     600.    88.     4.9     0.8
03
04
05
06
07
08
09ALAMEDA COUNTY        550.
10
      1978        6                             1.
1112  171113  101119  371120 1391121  161122  041201  361217  391218  051219  01
0103  100104  030105  010107  340108 1240109  180110  780111 1800114 1430115  28
0117  240130  010203  010213 1110214  090215  010216  490217  010218  450219  06
0220  740221  410222  640223  180225  070226  090228  580301  010303  030315  05
0316  690317  010326  400327 1450328  130406  020409  010416  050417  040422  04
0423  110425  010426  37
9999999999999999999999
01WALLECK CREEK
020PEN                  0.26    5.0     590.    59.     3.0     0.4
03
04
05
06
07
08
09MARIN COUNTY          3640.
10
      1978        8                             1.
0906  030909  010910  920911  141113  291116  031119  191120 1031121  061122  22
1123  201201  391205  041217  141218  961219  031228  080104  230105  030106  02
0108 1620109 1700110  060111 2750112  470113  020114 1900115 1770116  050118  38
0130  120131  790202  010213 1470214 1420215  020216  850217  020218  550219  11
0220  220221 1550222  560223  270224  040226  560301 1000302  010303  170304  04
0314  040315  040316  740317  250319  010322  010327 1650328  060329  030406  41
0407  030411  060416  030417  210422  040423  700424  050426  080427  300505  45
0506  450507  170508  01
9999999999999999999999999
```

Source: [6].

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

TABLE 21. MATADERO CREEK 24-HOUR COMPARISON - CALIBRATION RUN 1

Storm date		Flow, Mgal	BOD, lb	SS, lb	VSS, lb	N, lb	P, lb
2-13	MAC	13.3	1,000	106,000	14,000	554	67
	Measured	3.6	215	11,152	2,030	121	9
	Ratio[a]	3.7	4.7	9.5	6.9	4.6	7.4
2-20	MAC	3.5	0	28,000	4,000	148	18
	Measured	8.3	882	152,961	16,116	750	53
	Ratio	0.4	--	0.18	0.25	0.20	0.34
2-28	MAC	2.7	0	21,000	3,000	111.	13.
	Measured	1.1	49	6,884	1,095	38	6
	Ratio	2.5	--	3.1	2.7	2.9	2.2
3-26	MAC	4.0	0	32,000	4,000	116	20
	Measured	3.1	149	13,736	2,947	110	15
	Ratio	1.3	--	2.3	1.36	1.05	1.33
Summation	MAC	23.5	1,000	187,000	25,000	929	118
	Measured	16.1	1,295	184,733	22,188	1,019	83
	Ratio	1.6	0.77	1.0	1.1	0.91	1.4
	Avg 3 February storms	2.2	--	4.3	3.3	2.6	3.3
	Avg 4 (all)	1.98	--	3.77	2.8	2.19	2.8

a. Ratio = MAC/Measured.

Source: [6].

to watershed storm totals. Individual storms would be examined to ascertain that individual storms were adequately modeled (within a reasonable confidence limit), but exact storm fit was not set as a goal. The arithmetic average of individual storm ratios, in a similar fashion was examined to try and minimize variability; however, the summation ratio remained the controlling factor in establishing the input parameters for the second set of calibration runs.

The first calibration of simulated to measured ratios for Matadero Creek for the four storm summation varied from 0.77 for BOD to 1.6 for flow. the results are acceptable for a broad scale model; however, a slightly lowered runoff coefficient (of 0.06) was chosen for the second run to help model results more closely fit the data. No individual pollutant had unusually high variability so the input concentrations remained the same.

The Bear Creek comparison showed ratios of from 1.9 for SS to 4.0 for flow. Here again, flow showed the greatest deviation from the measurements so the second run used a runoff coefficient of 0.05. The pollutants all had close ratios so lowering the flow would tend to bring them closer to agreement with measured. No singular, high variability indicated the need to modify any of the pollutant input concentrations.

BEGIN LAST LINE OF TEXT
3/8"
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

TABLE 22. BEAR CREEK 24-HOUR COMPARISON - CALIBRATION RUN 1

Storm date		Flow, Mgal	BOD, lb	SS, lb	VSS, lb	N, lb	P, lb
1-8	MAC	0.2	0	2,000	0	3	4
	Measured	0.6	16	2,344	290	1	5
	Ratio[a]	0.33	--	0.85	--	3.0	0.8
1-10, 11	MAC	8.9	0	97,000	10,000	120	171
	Measured	0.4	39	4,988	1,097	10	22
	Ratio	22.2	--	19.5	9.1	12.0	7.8
2-13, 14	MAC	9.1	0	98,000	10,000	121	173
	Measured	2.7	205	93,592	7,397	68	147
	Ratio	3.4	--	1.05	1.35	1.8	1.2
3-27	MAC	5.6	0	61,000	6,000	75	108
	Measured	2.3	141	36,986	2,952	67	40
	Ratio	2.4	--	1.7	2.0	1.1	2.7
Summation	MAC	23.8	0	258,000	26,000	319	456
	Measured	6.0	401	137,910	11,736	146	214
	Ratio	4.0	--	1.9	2.2	2.2	2.1
	Avg (4)	7.1	-- (1.0)	5.8	4.2	4.5	3.1

a. Ratio = MAC/Measured

Source: [6].

TABLE 23. HALLECK CREEK 24-HOUR COMPARISON - CALIBRATION RUN 1

Storm date		Flow, Mgal	BOD, lb	SS, lb	VSS, lb	N, lb	P, lb
1-8	MAC	41.6	2,000	202,000	20,000	1,042	139
	Measured	1.49	74	2,768	573	42.5	6
	Ratio[a]	28	27	73	35	25	23
1-11	MAC	70.7	3,000	342,000	35,000	1,769	236
	Measured	29.4	1,227	226,829	18,902	570	49
	Ratio	2.4	2.4	1.3	1.9	3.1	4.8
2-13	MAC	37.8	2,000	183,000	19,000	946	126
	Measured	36.3	1,513	181,908	16,042	963	121
	Ratio	1.0	1.3	1.0	1.2	1.0	1.0
Summation	MAC	150.1	7,000	727,000	74,000	3,757	501
	Measured	67.2	2,814	411,505	35,517	1575.5	176
	Ratio	2.2	2.5	1.8	2.1	2.4	2.9
	Avg (3)	10.5	10	25	13	9.7	9.6

a. Ratio = MAC/Measured.

Source: [6].

TABLE 24. SEAVIEW - CASTRO VALLEY - CALIBRATION RUN 1

Storm date		Flow, Mgal	BOD, lb	SS, lb	VSS, lb	N, lb	P, lb
1-8	MAC	1.7	0	8,000	1,000	68	11
	Measured	0.5	--	1,258	--	--	2
	Ratio[a]	3.4	--	6.4	--	--	5.5
1-14	MAC	1.9	0	10,000	1,000	79	13
	Measured	0.4	--	--	--	--	--
	Ratio	4.8	--	--	--	--	--
2-13, 14	MAC	1.6	0	8,000	1,000	66	11
	Measured	0.2	--	1,354	208	8	1
	Ratio	8.0	--	5.9	4.8	8.3	11
2-15, 16	MAC	0.7	0	3,000	0	28	4
	Measured	0.3	--	327	75	11	1 (0.6)
	Ratio	2.3	--	9.2	--	2.6	4
2-18, 19	MAC	0.7	0	3,000	0	2.8	5
	Measured	0.3	--	1,908	329	27	1.5
	Ratio	2.3	--	1.6	--	1.0	3.3
2-20	MAC	1.0	0	5,000	1,000	41	7
	Measured	5.0	--	15,488	2,613	25	36
	Ratio	0.2	--	0.32	0.38	1.6	0.19
2-22	MAC	0.9	0	4,000	1,000	35	6
	Measured	2.7	--	8,640	1,163	53	6
	Ratio	0.33	--	0.46	0.86	0.66	1.0
2-28	MAC	0.8	0	4,000	1,000	32	5
	Measured	1.4	--	1,780	122	17	1.3
	Ratio	0.57	--	2.25	8.2	1.9	3.9
3-26, 28	MAC	2.6	0	14,000	1,000	109	18
	Measured	1.0	--	7,676	1,396	66	10
	Ratio	2.6	--	1.8	0.72	1.7	1.8
Summation	MAC	11.9	0	(8)40,000	(7)5,000	(7)339	(8)67
	Measured	11.8	--	38,431	5,906	207	58.4
	Ratio	1.0	--	1.0	0.85	1.6	1.2
	Avg[b]	2.7	--	3.5	3.0	2.5	3.8

a. Ratio = MAC/Measured.

b. As many as appropriate (varies 7-9).

Source: [6].

Halleck Creek with ratios from 1.8 for SS and 2.9 for phosphorus was also estimating uniformly high, so a runoff coefficient of 0.25 was chosen as the second input K value. Two storms modeled by ABMAC matched measured values very closely. One storm appears to account for most of the variability seen in this watershed. The Seaview watershed showed ratios from 0.85 for VSS to 1.6 for nitrogen, which is acceptable. However, in an effort to fit the model slightly closer, a phosphorus value of 0.7 mg/l and runoff coefficient of 0.07 were chosen as new second run input values.

The results of the second calibration run are tabulated for each station in Tables 25 through 28. Matadero Creek and Seaview results were within ± 40 percent of measured. Thus, both of these stations were classified as being as closely calibrated as is feasible given the data sampling and model constraints. Halleck Creek still seemed to be a factor of two too high so a third calibration run with a runoff coefficient of 0.12 was executed. The results, given in Table 29, show results within ± 30 percent of measured, which was accepted as adequate.

TABLE 25. BEAR CREEK 24-HOUR COMPARISON - CALIBRATION RUN 2

Storm date		Flow, Mgal	BOD, lb	SS, lb	VSS, lb	N, lb	P, lb
1-8	MAC	0.2	7	1,797	180	2	3
	Measured	0.6	16	2,344	290	1	5
	Ratio[a]	0.33	0.44	0.77	0.62	2.0	0.6
1-10, 11	MAC	7.5	311	80,868	8,087	99	143
	Measured	0.4	39	4,988	1,097	10	22
	Ratio	19.	8.0	16.	7.4	9.9	6.5
2-13, 14	MAC	7.5	314	81,587	8,159	101	145
	Measured	2.7	205	93,592	7,397	68	147
	Ratio	2.8	1.5	0.87	1.1	1.5	1.0
3-27	MAC	4.7	196	51,037	5,104	63	90
	Measured	2.3	141	36,986	2,952	67	40
	Ratio	2.0	1.4	1.4	1.7	0.9	2.3
Summation	MAC	19.9	828	215,289	21,530	265	381
	Measured	6.0	401	137,910	11,736	146	214
	Ratio	3.3	2.1	1.6	1.8	1.8	1.8
	Avg (4)	6.0	2.8	4.8	2.7	3.6	2.6

a. Ratio = MAC/Measured.

Source: [6].

TABLE 26. MATADERO CREEK 24-HOUR COMPARISON - CALIBRATION RUN 2

Storm date		Flow, Mgal	BOD, lb	SS, lb	VSS, lb	N, lb	P, lb
2-13	MAC	11.4	665	91,241	12,356	475	57
	Measured	3.6	215	11,152	2,030	121	9
	Ratio[a]	3.2	3.1	8.2	6.1	3.9	6.3
2-20	MAC	3.0	177	24,331	3,295	127	15
	Measured	8.3	882	152,961	16,116	750	53
	Ratio	0.36	0.20	0.16	0.20	0.17	0.28
2-28	MAC	2.3	133	18,248	2,471	95	11
	Measured	1.1	49	6,884	1,095	38	6
	Ratio	2.1	2.7	2.7	2.3	2.5	1.8
3-26	MAC	3.4	200	27,372	3,707	143	17
	Measured	3.1	149	13,736	2,947	110	15
	Ratio	1.1	1.3	2.0	1.3	1.3	1.1
Summation	MAC	20.1	1,175	161,192	21,829	840	100
	Measured	16.1	1,295	184,733	22,188	1,019	83
	Ratio	1.3	0.91	0.87	0.98	0.82	1.2
	Avg (4)	1.7	1.8	3.3	2.5	2.0	2.4

a. Ratio = MAC/Measured.

Source: [6].

TABLE 27. HALLECK CREEK 24-HOUR COMPARISON - CALIBRATION RUN 2

Storm date		Flow, Mgal	BOD, lb	SS, lb	VSS, lb	N, lb	P, lb
1-8	MAC	40	1,670	193,765	19,711	1,002	134
	Measured	1.5	74	2,768	573	42.5	6
	Ratio[a]	27.	23.	70.	34.	24.	22.
1-11	MAC	68.0	2,836	328,923	33,459	1,701	227
	Measured	29.4	1,227	226,829	18,902	570	49
	Ratio	2.3	2.3	1.2	1.8	3.0	4.6
2-13	MAC	36.3	1,516	175,824	17,886	909	121
	Measured	36.3	1,513	181,908	16,042	963	121
	Ratio	1.0	1.0	0.97	1.1	0.94	1.0
Summation	MAC	144.3	6,022	698,512	71,056	3,612	482
	Measured	67.2	2,814	411,505	35,517	1,575.5	176
	Ratio	2.2	2.1	1.7	2.0	2.3	2.7
	Ratio avg 3 storms	10.1	8.8	24.	12.	9.3	9.2

a. Ratio = MAC/Measured.

Source: [6].

TABLE 28. SEAVIEW - CASTRO VALLEY - CALIBRATION RUN 2

Storm date		Flow, Mgal	BOD, lb	SS, lb	VSS, lb	N, lb	P, lb
1-8	MAC	1.5	62	7,419	1,088	61	9
	Measured	0.5	--	1,258	--	--	2
	Ratio[a]	3.0	--	5.9	--	--	4.5
1-14	MAC	1.7	71	8,555	1,255	70	10
	Measured	0.4	--	--	--	--	--
	Ratio	4.25	--	--	--	--	--
2-13, 14	MAC	1.4	59	7,179	1,053	58	9
	Measured	0.2	--	1,354	208	8	1
	Ratio	7.0	--	5.3	5.1	7.3	9.0
2-15, 16	MAC	0.6	24	2,992	439	24	3
	Measured	0.3	--	327	75	11	0.6
	Ratio	2.0	--	9.2	5.9	2.2	5.0
2-18, 19	MAC	0.6	25	3,051	448	25	3
	Measured	0.3	--	1,908	329	27	1.5
	Ratio	2.0	--	1.6	1.4	0.93	2.0
2-20	MAC	0.9	37	4,427	649	36	5
	Measured	5.0	--	15,488	2,613	25	36
	Ratio	0.18	--	0.29	0.25	1.4	0.14
2-22	MAC	0.8	32	3,829	562	31	4
	Measured	2.7	--	8,640	1,163	53	6
	Ratio	0.30	--	0.44	0.48	0.58	0.67
2-28	MAC	0.7	29	3,470	509	28	4
	Measured	1.4	--	1,780	122	17	1.3
	Ratio	0.50	--	2.0	4.2	1.7	3.1
3-26, 28	MAC	2.4	98	11,846	1,737	97	11
	Measured	1.0	--	7,676	1,396	66	10
	Ratio	2.4	--	1.5	1.2	1.5	1.1
Summation	MAC	10.6	1,337	44,213	5,397	299	48
	Measured	(9)11.8	--	(8)38,431	(7)5,906	(7)207	(8)58.4
	Ratio	0.90	--	1.2	0.91	1.4	0.82
	Avg	2.4	--	3.3	2.7	2.2	3.2

a. Ratio = MAC/Measured.

Source: [2].

TABLE 29. HALLECK CREEK 24-HOUR COMPARISON - CALIBRATION RUN 3

Storm date		Flow, Mgal	BOD, lb	SS, lb	VSS, lb	N, lb	N, lb
1-8	MAC	19.2	802	93,007	9,461	481	64
	Measured	1.5	74	2,768	573	42.5	6
	Ratio[a]	12.8	10.8	33.6	16.5	11.3	10.7
1-11	MAC	32.6	1,361	157,883	16,060	817	109
	Measured	29.4	1,227	226,829	18,902	570	49
	Ratio	1.1	1.1	0.70	0.85	1.4	2.2
2-13	MAC	17.4	728	84,396	8,585	437	58
	Measured	36.3	1,513	181,908	16,042	963	121
	Ratio	0.48	0.48	0.46	0.54	0.45	0.48
Summation	MAC	69.2	2,891	335,286	34,106	1,735	231
	Measured	67.2	2,814	411,505	35,517	1,575.5	176
	Ratio	1.0	1.0	0.81	0.96	1.1	1.3
	Avg 3 storms	4.8	4.1	11.6	6.0	4.4	4.5

[a] Ratio = MAC/Measured.

Source: [6].

The second calibration run results for Bear Creek showed flow about 3 times high but pollutants only 2 times high. To balance simulated to measured results, the runoff coefficient was reduced by 1/3. The pollutant concentrations only need a net change of 1/2. As the flow correction of 1/3 would also influence the pollutant loads, a net modification of 3 x 1/2 or 3/2 was applied to derive new pollutant input values. The third calibration run input values were chosen as runoff coefficient = 0.02, BOD = 7, SS = 1900, VSS = 150, N = 2.4, and P = 3.2.

The third calibration results for Bear Creek are shown in Table 30. The resulting model estimates are within ±30% of measured values.

EVALUATION OF RESULTS

Daily Calibration of Individual Watersheds

Starting from average pollutant concentrations and runoff coefficients derived from measured data, only slight modifications for runoff coefficient values were required to bring the simulated to measured ratio to within ± 40 percent for three of the subareas. Substantial runoff and concentration coefficient changes were required to bring the model to within ± 30 percent of measured data for Bear Creek.

The final calibration values for all four watersheds are listed in Table 31. The pollutant concentrations are within expected limits when compared to previously reported values and the runoff coefficients are

TABLE 30. BEAR CREEK 24-HOUR COMPARISON - CALIBRATION RUN 3

Storm date		Flow, Mgal	BOD, lb	SS, lb	VSS, lb	N, lb	P, lb
1-8	MAC	0.1	4	1,051	83	1	2
	Measured	0.6	16	2,344	290	1	5
	Ratio[a]	0.17	0.25	0.45	0.29	1.0	0.40
1-10, 11	MAC	2.9	174	47,276	3,733	60	80
	Measured	0.4	39	4,988	1,097	10	22
	Ratio	7.25	4.46	9.5	3.4	6.0	3.6
2-13, 14	MAC	3.0	176	47,697	3,765	60	81
	Measured	2.7	205	93,592	7,397	68	147
	Ratio	1.1	0.86	0.51	0.51	0.88	0.55
3-27	MAC	1.9	110	29,837	2,356	38	50
	Measured	2.3	141	36,986	2,952	67	40
	Ratio	0.83	0.78	0.81	0.80	0.57	1.3
Summation	MAC	7.9	464	125,861	9,937	159	213
	Measured	6.0	401	137,910	11,736	146	214
	Ratio	1.3	1.2	0.91	0.85	1.1	1.0
	Avg 4 storms	2.3	1.6	2.8	1.3	2.1	1.5

a. Ratio = MAC/Measured.

Source: [6].

TABLE 31. FINAL CALIBRATION INPUT VALUES

	Runoff coefficient	BOD, mg/L	SS, mg/L	VSS, mg/L	N, mg/L	P, mg/L
Matadero	0.06 [0.12] (0.05-0.39)	7 (5.4-12.7)	960 (368-2,202)	130 (67-232)	5.0 (4-10.8)	0.6 (0.3-0.8)
Bear	0.02 [0.11-0.20] (0.014-0.45)	7 (3.1-7.4)	1,900 (448-2,075)	150 (55-164)	2.4 (0.19-3.5)	3.2 (1.0-3.3)
Halleck	0.12 [0.26-0.30] (0.02-0.60)	5 (5-5.9)	580 (222-924)	59 (46-77)	3.0 (2.3-3.4)	0.4 (0.2-0.5)
Seaview	0.08 [0.15-0.17] (0.03-1.1)	5 --	600 (228-1,010)	88 (26-138)	4.9 (1.3-8.1)	0.7 (0.3-1.9)

Note: ( ) = range data this sampling.
[ ] = range reported in ABAG Surface Runoff Study. [2]

Source: [6].

approximately half the level reported in the ABAG Surface Runoff Modeling Study (see Table 4).

Calibration Summary

Through a series of daily calibration runs, the ABMAC model was able to calculate flow and pollutant loads to within ± 40 percent of measured data for all four subareas. Considering the broad scale of the model, the accuracy achieved is acceptable. The runoff coefficient and pollutant concentrations derived in this calibration effort for short, individual storm events must undergo interpretation and modification before being used as input for yearly ABMAC applications.

Model Sensitivity

The term sensitivity refers to the potential variation in model output in response to changes in individual input parameters. Input variables with high sensitivity require more careful examination during selection. Sensitivities of the input parameters to ABMAC were demonstrated by using examples selected to illustrate responses to runoff coefficient and concentration changes. Alteration of the runoff coefficient produces a directly proportional effect on runoff volume. Two examples using data from Halleck Creek and Bear Creek were used:

Example 1:	This example is used to show that for either a small (4 percent) or a larger (52 percent) reduction in the runoff coefficient for the Halleck Creek, the calculated flow was reduced in the same proportion. The results are shown in Table 32.
Example 2:	This example demonstrates that the ratio between runoff coefficients is the same as the observed ratio between flows. Data from Bear Creek were used. This example illustrates also the pollutant concentration sensitivity. The change in input concentrations was not the only factor influencing calculated loads. The flow change was also a factor. Flow had a multiplicative effect on calculated pollutant loads. In the example, the flow ratio when multiplied by a pollutant ratio produced a number which matched the ratio of change observed in the calculated load. (see Table 32).

These two examples show that the runoff coefficient to be more sensitive because an error in that parameter had a subsequent effect on pollutant loads.

Rainfall and area input also have directly proportional influences on the ABMAC results. Doubling the rainfall or watershed size doubles the runoff quantity if the runoff coefficient is held constant. The rainfall and area data should be determined as accurately as possible

TABLE 32. EXAMPLES OF PARAMETER SENSITIVITY

Example 1: Halleck Creek

	Input runoff coefficient	Ratio change	MAC flow calculated, Mgal[a]	Ratio change
Calibration run 1	0.26	--	150.1	--
Calibration run 2	0.25	0.96	144.3	0.96
Calibration run 3	0.12	0.48	69.2	0.48

---

a. Total for all storms modeled.

Example 2: Bear Creek

Input results	Runoff coefficient Flow, Mgal	BOD mg/L lb	SS mg/L lb	VSS mg/L lb	N mg/L lb	P mg/L lb
Calibration 2 input	0.05	5	1,300	130	1.6	2.3
Calibration 3 input	0.02	7	1,900	150	2.4	3.2
Ratio 2/3	2.5	0.71	0.68	0.87	0.66	0.72
Flow ratio x concentration ratio	--	1.78	1.70	2.18	1.65	1.80
Calibration 2 results	19.9	828	215,289	21,530	265	381
Calibration 3 results	7.9	464	125,861	9,930	159	213
Ratio 2/3	2.5	1.78	1.72	2.17	1.67	1.79

Note: Upper parameter units apply to inputs shown on upper portion of the table and lower units apply to results shown on lower portion of the table.

Source: [6].

since these data are usually readily obtained. This should be done to maximize overall accuracy as other input data are inherently more variable and more difficult to estimate.

Input Parameter Recommendations

In this section, some typical ABMAC input parameters developed from the calibration effort and a methodology to be used in developing input parameters are presented. The suggested input parameter values are listed in Table 33.

The input values developed in the calibration section are labeled as daily in Table 33. These values are applicable for individual storm

TABLE 33. SUGGESTED INPUT PARAMETERS FOR THE WATERSHEDS

	Runoff coefficient	BOD, mg/L	SS, mg/L	VSS, mg/L	Total N as N, mg/L	Total P as P, mg/L
Matadero Creek						
Daily 24 hr	0.06	7	960	130	5.0	0.6
Dry year adjusted	0.07					
Individual storm	(0.16-0.20)					
Yearly	0.12	3	480	65	2.5	0.3
ASRR[a]	(0.12)					
Bear Creek						
Daily 24 hr	0.02	7	1,900	150	2.4	3.2
Yearly	0.04	3	950	75	1.2	1.6
ASRR	(0.11-0.20)					
Halleck Creek						
Daily 24 hr	0.12	5	580	59	3.0	0.4
Yearly	0.24	2	290	30	1.5	0.2
ASRR	(0.26-0.30)					
Seaview						
Daily 24 hr	0.08	5	600	88	4.9	0.7
Yearly	0.16	2	300	44	2.4	0.3
ASRR	(0.15-0.17)					

a. Values reported in ABAG Surface Runoff Report [2].

Source: [6].

analyses. As ABMAC is designed for yearly operation, the daily numbers have value only for calibration applications. Two additional daily runoff coefficient values are shown in this table for Matadero Creek. The first illustrates the change in the runoff coefficient to compensate for the rain season being 18 percent drier than normal. The second range of values are the runoff coefficients observed during the direct surface runoff portion of the storm (the low flow runoff condition for 24-hour comparison is not included).

Also listed in Table 33 for comparison purposes are the runoff coefficients reported in the ABAG Surface Runoff Report [2]. The values of greatest interest, however, are the recommended yearly input parameters. The contribution of delayed direct runoff when analyzing yearly flow volumes and pollutant loads cannot be neglected. The daily

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

input parameters were taken as a starting point and then modified. It was assumed that half of the total flow volume comes from delayed direct runoff. All of the yearly runoff coefficients are therefore twice the computed daily values, which brings the coefficients into the range reported in ABAG Surface Runoff Study. To offset the flow change (multiplier effect) the pollutant concentrations are reduced by 50 percent.

An additional reduction in pollutant concentrations may be warranted as the 50 percent reduction mainly compensates for doubling the daily flow value. The concentrations may need an additional reduction to account for very low pollutant concentrations in delayed runoff. Without further data to substantiate such an action only the first reduction is recommended at this time.

The values in Table 33 apply only to the specific watersheds analyzed. Should these values be used on other open space watersheds, general characteristics and similarities between the two areas must be examined to determine applicability.

6-1/2"
9-1/8"
BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

SECTION 7

MODEL USE AND RECOMMENDATIONS

With adequate calibration, the ABMAC can be used effectively in the planning phase of nonpoint source pollution control studies. Typical problems for which the ABMAC can be applied include:

(1) expected changes in pollutant loadings from urbanization

(2) long-range pollutant loadings to water bodies under existing conditions

(3) general impact of land use changes on nonpoint pollution

(4) evaluation of BMP's and their relative impact on water quality

One of the guidelines developed by U.S. Environmental Protection Agency [11] for nonpoint pollution evaluation includes the use of the following formula:

$$N = (Q + S + D) - (P + I)$$

where;

N = Quantity (mass) of nonpoint source pollutants in terms of a given parameter, under a given design flow condition
Q = Quantity of pollutants in the water leaving the test area
S = Quantity of settlement and precipitation of pollutants
D = Quantity of decay of nonconservative pollutants
P = Quantity of pollutants discharged by point sources (assumed to be constant under a given design flow condition)
I = Quantity of pollutants in the water entering the test area

This formula calculates the total nonpoint pollutant loading under the design conditions. ABMAC can be used for estimating values of N, the nonpoint pollutant loadings from the various land uses in a large area. Reasonably accurate estimates can be obtained when local data, good judgment and caution are used in selecting model parameters.

Instructive values for model coefficients are provided in Section 6 on model calibration and testing. It is however, important to develop similar values for specific watersheds to which the model is applied.

6-1/2"
9-1/8"
BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

For estimation of runoff coefficients, a sampling program similar to that for calibration could be conducted to estimate daily runoff coefficients for several storms. These values would then be modified to yearly numbers. A more exact method of determining the yearly runoff coefficient would involve yearly rainfall and flow records. If rainfall and flow records are available this method is easier and more accurate. If flow records are not available, a recording flow meter could be installed for one season to obtain the necessary information. Due to the sensitivity of the runoff coefficient, the estimate should be as accurate as feasible.

Development of pollutant input parameters should include quality samples during both high and low storm flow conditions. If immediate runoff is estimated as being equal in size to delayed runoff, averages of the two concentrations are probably the best estimates of yearly pollutant inputs for the model.

The key outputs of a calibrated ABMAC watershed are the volume of runoff and the mass loadings of pollutants. The equations that define the output are:

6-1/2"

$$\text{Runoff volume} = \sum_{1}^{n} KRA$$

$$\text{Mass loading of pollutant X} = \sum_{1}^{n} 0.227\ KRAC_X$$

9-1/8"

where K = dimensionless runoff coefficient,
R = rainfall in inches,
A = area in acres,
C_X = average concentration of pollutant X in mg/l,
n = number of land use types in watershed, each with its own runoff coefficient, precipitation record, area, and average pollutant concentration, and
0.227 = constant conversion unit for pollutant load into pounds.

Looking at these relationships, it is seen that options increasing infiltration can be simulated by decreasing the value of "K" and consequently decreasing both runoff volume and pollutant loading on the land surface are simulated by decreasing the "C" value for a specific pollutant and land use. Finally, all or part of the runoff from a subarea can be put through a subroutine that simulates storage or treatment. The storage part controls the rate of runoff from an area but does not affect the volume or pollutant loading. The treatment option reduces the pollutant concentration to a specified value simulating the chosen treatment option.

In applying ABMAC for mitigation measure assessment, a simple five step procedure is recommended:

1. Compute ABMAC coefficients based on field data or other specific source.

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

2. Specify runs that are to be made with ABMAC:
   - Existing conditions
   - Set of future conditions
   - Specific watershed affected

3. Enter coefficients into ABMAC and initiate runs

4. Summarize output

5. Draw conclusions concerning impacts

The coefficients that are available for evaluating a range of control alternatives include the following:

- "K" the gross runoff coefficient of runoff/rainfall

- "C" the concentration of a specific pollutant for a specific land use

- The fraction of total land use allocated to each specific land use

- The specified storage that modifies rate of runoff but not volume

- The specified treatment that reduces the pollutant loading

Table 34 indicates the interface of ABMAC with various control measures. The difficult part in assessing the effect of various mitigation measures is determining how much must the model coefficients be modified to properly reflect the impact of a specific control measure. Unfortunately there is no clear cut answer to this problem. In some cases, results of other studies might be applicable. In other cases, site specific applications of more refined models, such as SWMM, might be used as an alternative for providing more accurate input information. To some extent, there will always be a need to exercise engineering experience and judgement in such evaluations. What must be emphasized, however, is that while some assumptions might be only approximate, the overall comparison of alternative results can be used with confidence in discriminating between different BMPs.

As is the case with most other models, ABMAC requires a good understanding of the system to be modeled and the effects of the model inputs. The Users Manual in Part II, should provide sufficient background for proficient model application.

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
DROPPED HEAD, BEGIN SECTIONS HERE
CENTER OF PAGE
TOP OF IMAGE AREA
9-1/8"
6-1/2"
BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

TABLE 34. INTERFACING ABMAC WITH CONTROL MEASURES

SURFACE RUNOFF CONTROL MEASURES												
More frequent street cleaning	Repair streets	Control chemical use	Slope density standards	Control development patterns	Control roof drains	Rooftop storage	Reseed bare slopes	Require pervious areas	Off-line storage	Treatment facilities	ABMAC INPUT	EFFECTS
					●			●			Decrease ratio of runoff/rainfall	Decrease runoff, decrease pollution
											Decrease pollutant concentrations	Decrease pollution
●	●						●				Solids	
●											Organics	
		●									Nutrients	
											Bacteriological indicators	
		●									Toxins	
											Modify the land use distribution	
			●								Increase % of open land	Decrease runoff, decrease pollution
				●							Decrease % of industrial land	Decrease runoff, decrease pollution
				●							Decrease % of commercial land	Decrease runoff, decrease pollution
						●			●		Implement storage option	Decrease peak flow
										●	Implement treatment option	Decrease pollution

EPA-287 (Cin.)
(4-76)

REFERENCES

1. Association of Bay Area Governments. ABAG/MTC Series 3 Modeling System, Working Paper No. 36. October 28, 1976.

2. Association of Bay Area Governments, Environmental Management Plan, Appendix D - Surface Runoff Technical Materials, Edited by Y.J. Litwin, June 1978.

3. California State Water Resources Control Board. Dispersion Capability of San Francisco Bay-Delta Waters, Final Report. Publication No. 45. August 1972.

4. Fischer, Hugo B. A Review and Comparison of Salinity Models for the San Francisco Bay-Delta System. Report for the U.S. Bureau of Reclamation, Sacramento, California. May 1976.

5. Frommer, R. H., et al. The Impact of Surface Runoff on San Francisco Bay. ASCE Annual Fall Convention and Exhibit, San Francisco, CA. October 17-21, 1977.

6. Lager, J.A., et al. Surface Runoff Modeling. Report to the Association of Bay Area Governments, San Francisco Bay Region, April 1978.

7. Lager, J.A., T. Didriksson, and G.B. Otte. Development and Application of a Simplified Stormwater Management Model. Report EPA-600/2-76-218 to U.S. Environmental Protection Agency. August 1976.

8. Lager, J.A., et al. Urban Stormwater Management and Technology-Update and Users' Guide. Report for the U.S. Environmental Protection Agency, EPA-600/8-77-014. September 1977.

9. Resource Management Associates. Calibration and Verification of the Site-Specific Surface Runoff Model-ABAG 208 Surface Runoff Program. June 3, 1977.

10. U.S. Environmental Protection Agency. Areawide Assessment Procedures Manual, 3 Volumes, EPA-600/9-76-014. July 1976.

11. U.S. Environmental Protection Agency. Methods for Identifying and Evaluating the Nature and Extent of Nonpoint Sources of Pollutants. EPA-430/9-73-014. October 1973.

12. University of Florida and The American Public Works Association, Nationwide Evaluation of Combined Sewer Overflows and Urban Stormwater Discharges, Volume I: Executive Summary, U.S. Environmental Protection Agency, EPA-600/2-77-064a. March 1977.

PART II. ABMAC USERS MANUAL

INTRODUCTION

The Association of Bay Area Governments (ABAG) Macroscopic Water Quality Model (ABMAC), was specifically developed to provide a relatively inexpensive, reasonably accurate, and flexible tool for the planning and preliminary sizing of stormwater facilities.

The model is designed to simulate runoff caused by rainfall, storage, and treatment balances and to assess the magnitude of runoff and storage withdrawals. All simulated quantities are calculated on a daily basis. Use of ABMAC helps to promote the development of overall system priorities for pollutant control. In addition, the low cost of setting up and operating this model makes it ideally suited for easy and rapid determination of the relative merits of alternative plans or assumptions.

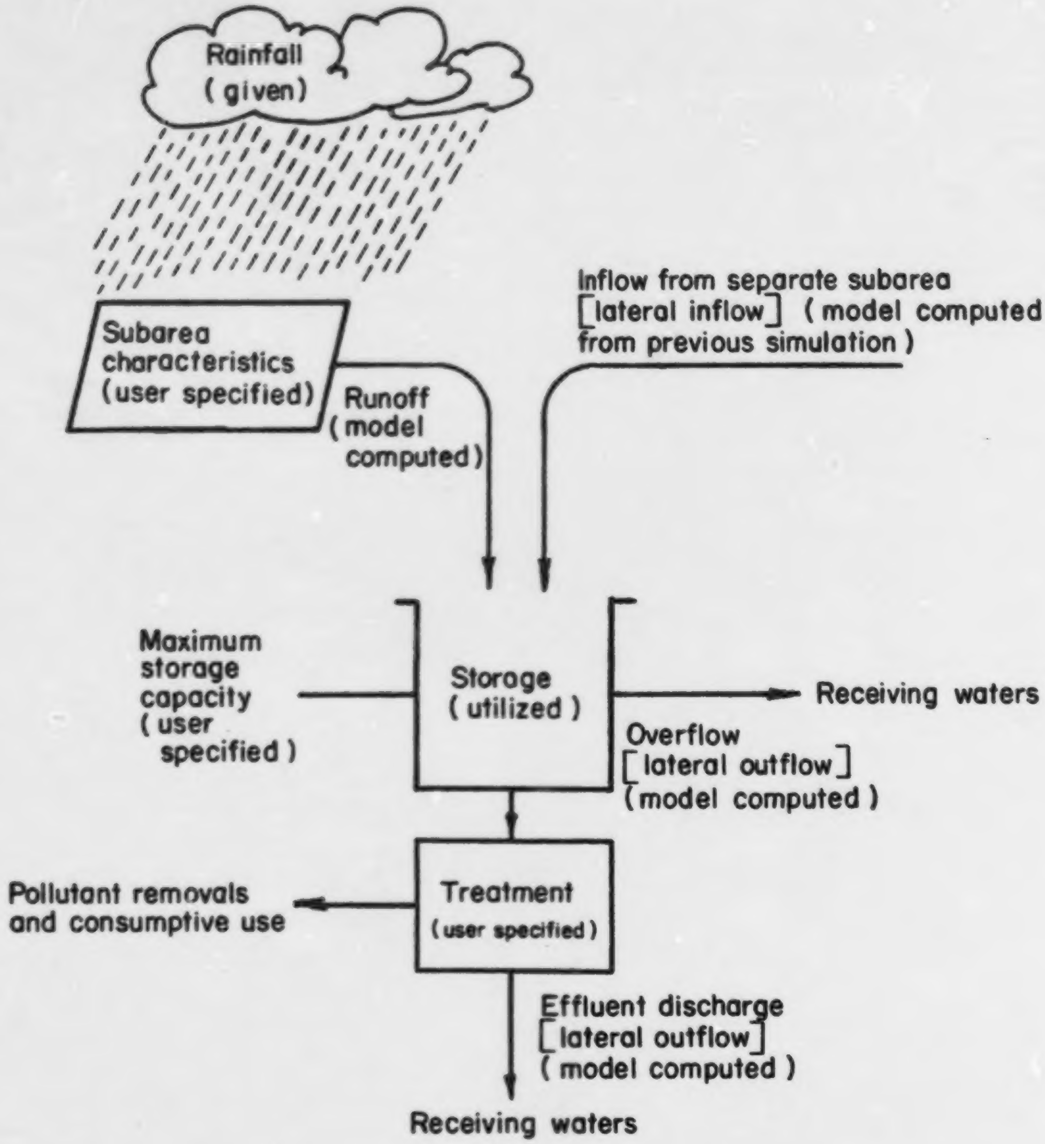
The source listing for the latest version of ABMAC, the ABMAC3M is shown in Appendix B. It is a successor to the ABMAC version discussed in Section 4 of this report. ABMAC has been restructured to facilitate future modifications, allow greater user flexibility, and incorporate many new features and capabilities which greatly enhance model applicability. This version has also been modified for minicomputer compatibility.

MODEL STRUCTURE AND OPERATION

Given a rainfall history, ABMAC computes runoff from different land use areas and combines these with lateral inflows to a given segment or subarea of the watershed. If storage exists within such computational unit, ABMAC can compute the treated withdrawals from such storage, if desired, and determine resulting storage volumes and overflows, if any. All computations are repeated on a daily basis. A schematic representation of the ABMAC concept is shown in Figure A-1.

The ABMAC computer code prints out the status of all variables on either a daily, monthly, yearly or subareal basis depending on user preference. Also output are summaries for each water year, subarea and total run. ABMAC can repeat the above process for many subareas within the same run. In addition the daily withdrawals and/or overflows from storage may be written on disk files for future use as input (lateral inflows) to downstream segments.

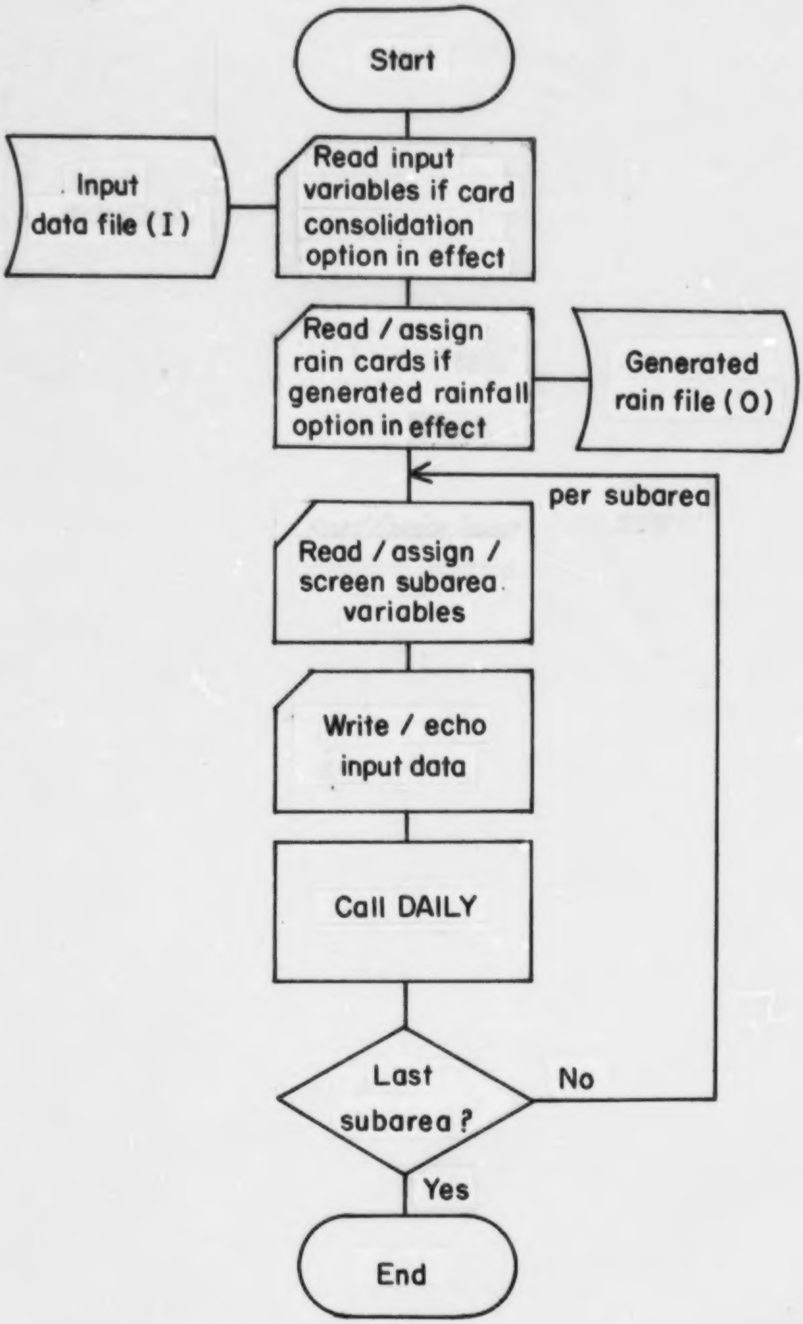
Simplified flow charts of the ABMAC MAIN program segment and DAILY subroutine, are provided in Figures A-2 and A-3. Access points to external input and output (I/O) files are shown. A more detailed explanation of specific features follows. The features have been


Rainfall
(given)
Subarea characteristics (user specified)
Runoff (model computed)
Inflow from separate subarea [lateral inflow] (model computed from previous simulation)
Maximum storage capacity (user specified)
Storage (utilized)
Receiving waters
Overflow [lateral outflow] (model computed)
Pollutant removals and consumptive use
Treatment (user specified)
Effluent discharge [lateral outflow] (model computed)
Receiving waters

Note : Simulation repeated for each subarea (computational unit)

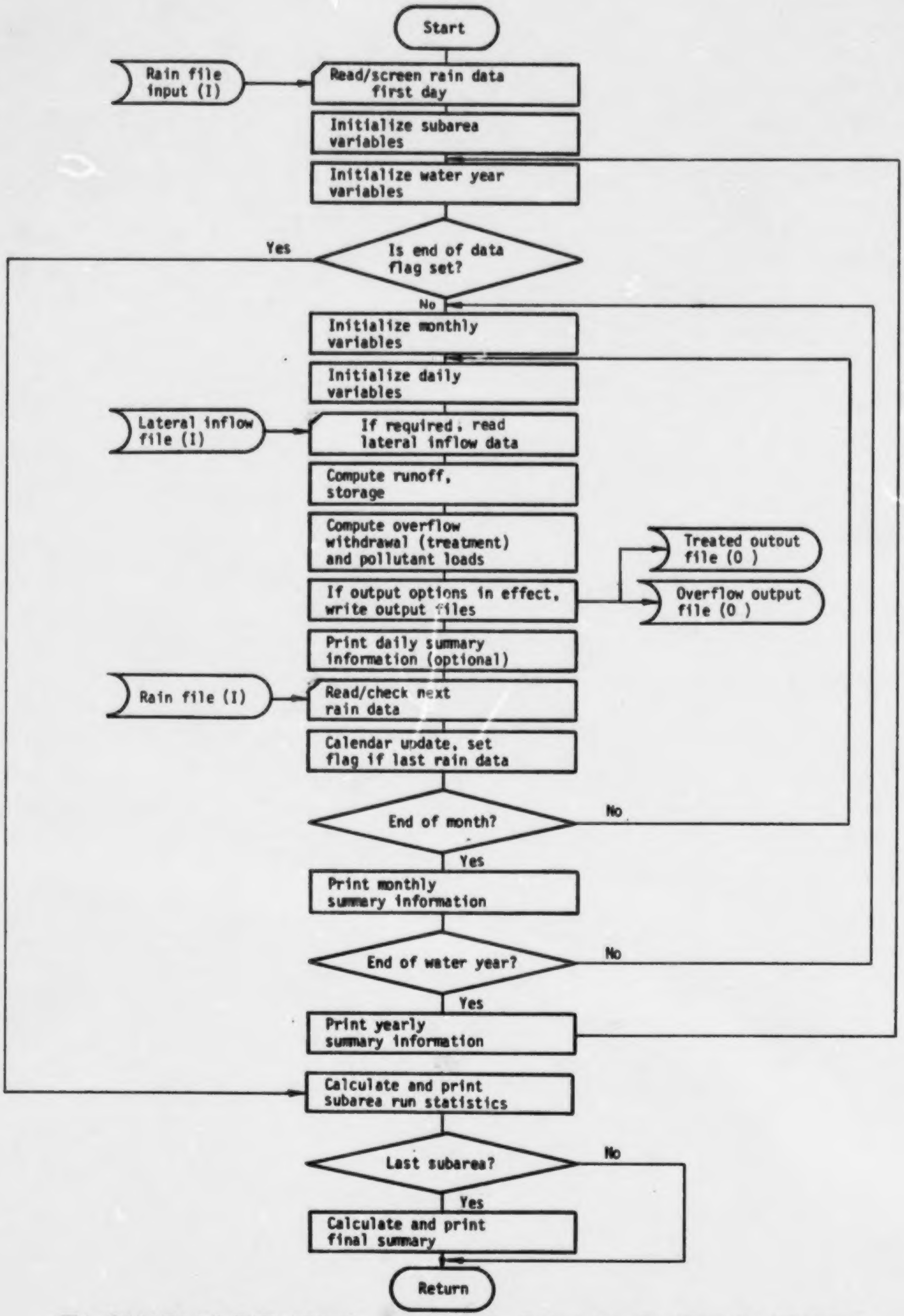
SCHEMATIC REPRESENTATION OF ABMAC CONCEPT

Figure A-1


Start
Input data file (I)
Read input variables if card consolidation option in effect
Read / assign rain cards if generated rainfall option in effect
Generated rain file (O)
per subarea
Read / assign / screen subarea variables
Write / echo input data
Call DAILY
Last subarea ?
No
Yes
End

FLOWCHART OF ABMAC MAIN SUBROUTINE

Figure A-2


Start
Rain file input (I)
Read/screen rain data first day
Initialize subarea variables
Initialize water year variables
Yes
Is end of data flag set?
No
Initialize monthly variables
Initialize daily variables
Lateral inflow file (I)
If required, read lateral inflow data
Compute runoff, storage
Compute overflow withdrawal (treatment) and pollutant loads
Treated outout file (O)
If output options in effect, write output files
Overflow output file (O)
Print daily summary information (optional)
Rain file (I)
Read/check next rain data
Calendar update, set flag if last rain data
End of month?
No
Yes
Print monthly summary information
End of water year?
No
Yes
Print yearly summary information
Calculate and print subarea run statistics
Last subarea?
No
Yes
Calculate and print final summary
Return

FLOWCHART FOR ABMAC DAILY SUBROUTINE

Figure A-3

6490

grouped in four categories: run input parameter, external I/O, printing options, and output format.

Run Input Parameter Options

The following list of options focuses primarily on quality characteristics available in the model.

- A rain factor, which is multiplied by the input rainfall to obtain the used rainfall. This enables adjustment for various subareas using the same master rain gage data, if several gages are available within the analyzed watershed.
- An overriding runoff coefficient for the entire subarea which, if nonzero, supplants any values prescribed for individual land uses.
- Four quality options for calculating and printing output constituent loads, as follows:

  a. Loads based on total runoff,
  b. Loads from overflows only,
  c. Loads from treated withdrawals only, or
  d. Loads from overflows and treated withdrawals.

- The water year definition, which can be set to start at any month of the calendar year.
- Number of subareas per run, maximum of 99, fewer if computer system limitations apply.
- Up to six land uses for each subarea can be specified. Each land use has its own area and runoff coefficient.
- Concentrations for six runoff quality constituents for each of the six land uses. One additional constituent can be user specified. The other five pollutants are biochemical oxygen demand (BOD), suspended solids (SS), volatile suspended solids (VSS), total nitrogen (TN), and total phosphorus (TP).
- Storage volume for the entire subarea. To compare effects of existing and future storage volumes two ABMAC runs are made; the first using existing storage volume only; the second using the total volume of existing and future storage facilities.
- Treated effluent concentrations for six quality constituents. An ABMAC run without treated effluent concentrations establishes the base quantity of pollutants generated. A second ABMAC run specifying expected effluent quality from a chosen treatment process then demonstrates the magnitude of improvement possible.

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

- o Treated withdrawal rates, which are used to specify treatment facility capacity. Other interpretations of the withdrawal rate are dewatering capacity for detention ponds or rate of evaporation/infiltration for retention ponds.

Extended I/O Options

A maximum of five external files can be opened in a run. All can be specified for a single subarea, if needed. Also, an output file can be generated from a subarea early in a run and then used as a lateral inflow later in the same run to enable combination of flows from different subareas (this ability is subject to minicomputer system limitations).

The use of the lateral inflow file enables the combining of flows from upstream areas. As an example assume a major watershed has three subareas A, B, and C. A and B drain into subarea C. The upstream subarea A is run first through ABMAC and generates an overflow file. Area B is run second using the A overflow file as a lateral inflow file. The B run also generates an overflow file which now is the summation of runoff volumes from areas A and B. The C area is run next using the B overflow file as a lateral inflow file. Thus the third run now has accumulated the entire runoff volume from the major watershed.

If subarea C has a wet weather treatment facility then the third run could also specify a treated output file and an overflow file. The overflow file in this last case represents watershed runoff above the capacity of the treatment facility. A listing of the various I/O options follows.

- o Run input may be read from a file on disk or from cards.

- o Daily rainfall input may be read from an existing file on disk or from cards. Also rainfall file and disk can be generated from card input.

- o One lateral inflow input may be read from a file on disk. The data read in includes flows and constituent qualities; however only the flows of lateral inputs are currently taken into account by the ABMAC code. The capability can be added to incorporate lateral inflow qualities. Lateral inflows are generated as output files from preceeding ABMAC runs.

- o Up to two output files may be written on disk for treated withdrawal or storage overflow quanity and quality.

Printing Options

A variety of printing and input format options are listed below enabling the user to shape the output to the specific level of detail required, and to limit the input data requirements to a minimum size.

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

EPA-287 (Cin.)
(4-76)

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

- o Daily, monthly, yearly, or subarea printing detail.
- o Monthly, yearly, subarea, and run summaries, both total and averages.
- o Variable format of input data allowing consolidation of repeated rain data and subarea information.

Output Format

The output from an ABMAC run consists of three parts: (1) a summary of input data, (2) the calculated output, and (3) a run summary.

The input summary consists of tabulated land use, area, quality and runoff coefficient information, followed by other specified input parameters. This first section serves as an identification aid for the following subarea results and serves as a double check that the parameters specified were indeed the parameters desired. This summary is printed for each subarea.

The calculated output follows this initial summary and consists of a heading and lines of results. Depending on the printing frequency option chosen, data will be listed daily for each month, or listed for all 12 months for each year, or yearly, or as subarea run totals. The type of results listed are the number of days of rain and inches of rain fall, the volume of runoff, overflow, treated withdrawal and maximum overflow storage utilized. Also listed are pollutant loads and the number of days of overflow and withdrawal.

The last section of output occurs after all of the subarea infomation. The run summary lists total average volumes and average number of rain days and inches of rainfall. The values are designed to indicate characteristics for regions containing the subareas specified in that run.

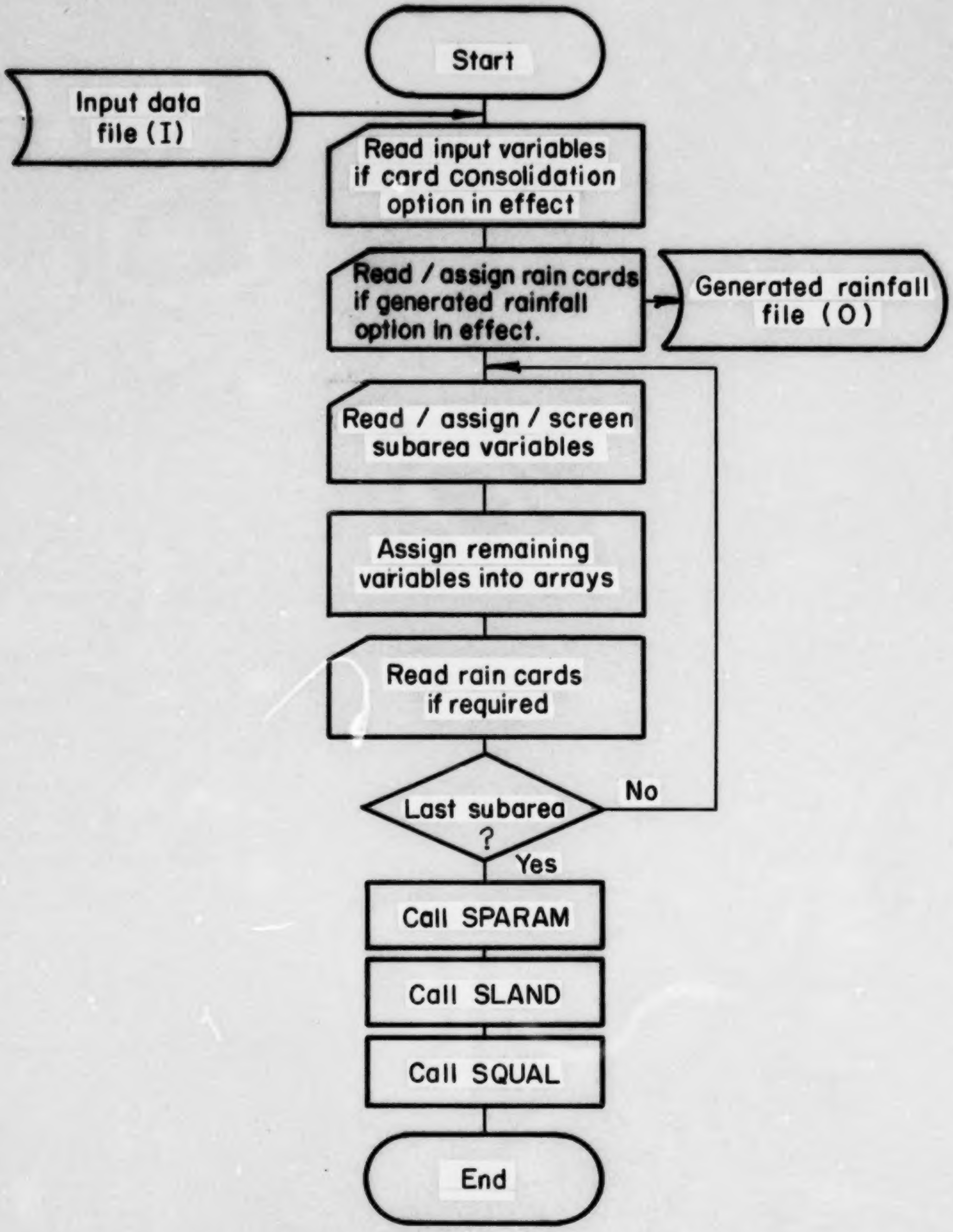
ABMAC SUPPORT PROGRAM

Associated with ABMAC is a program specially developed to process run input data without initiating the main model algorithm. Due to minicomputer size limitations this preprocessor had to be a separate program (DATACHKM). The program provides some error checking and tabulation of input data by subarea to allow the user to easily scan the data for inconsistencies. In addition, numerical values undergo simple statistical checks (totals, averages, maxima, and minima) to assist in data verification.

Input data sets after being preprocessed will successfully execute in an ABMAC run. Flow charts of DATACHKM and associated subroutines are shown in Figures A-4 to A-7.

BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
BEGIN LAST LINE OF TEXT
3/8"

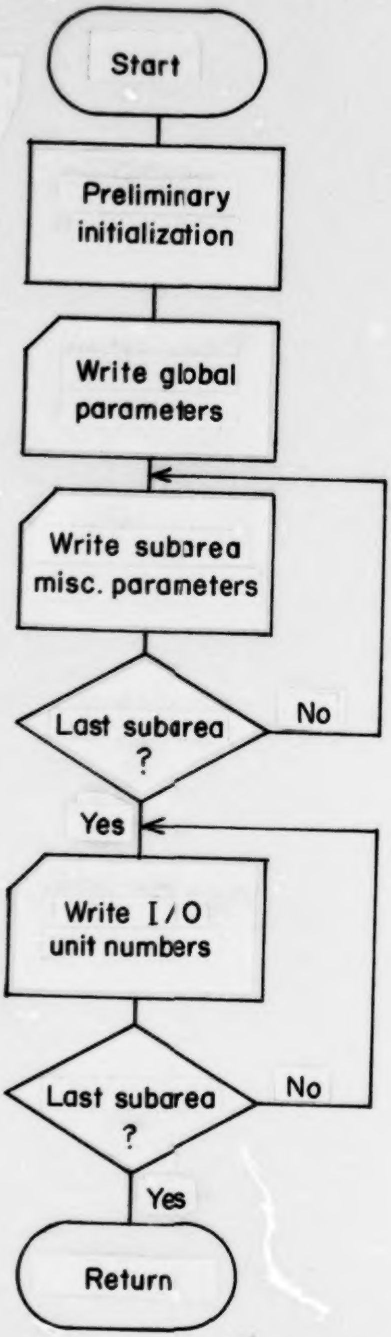
EPA-287 (Cin.)
(4-76)



Start
Input data file (I)
Read input variables if card consolidation option in effect
Read / assign rain cards if generated rainfall option in effect.
Generated rainfall file (O)
Read / assign / screen subarea variables
Assign remaining variables into arrays
Read rain cards if required
Last subarea ?
No
Yes
Call SPARAM
Call SLAND
Call SQUAL
End

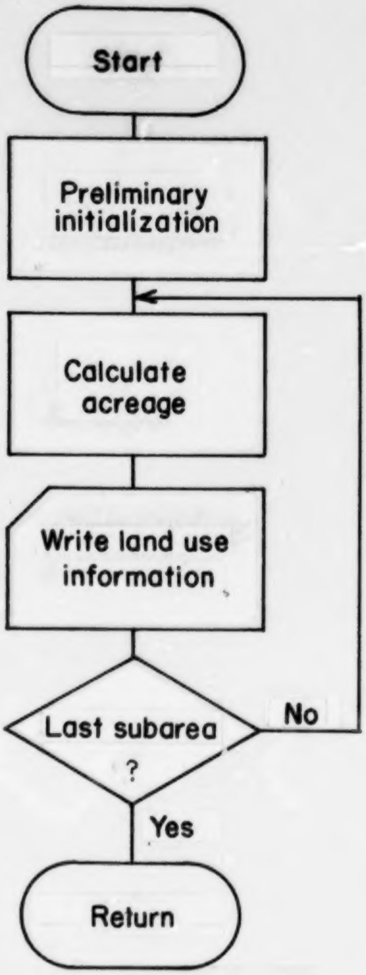
FLOWCHART FOR DATACHK MAIN SUBROUTINE

Figure A-4


Start
Preliminary initialization
Write global parameters
Write subarea misc. parameters
Last subarea ?
No
Yes
Write I/O unit numbers
Last subarea ?
No
Yes
Return

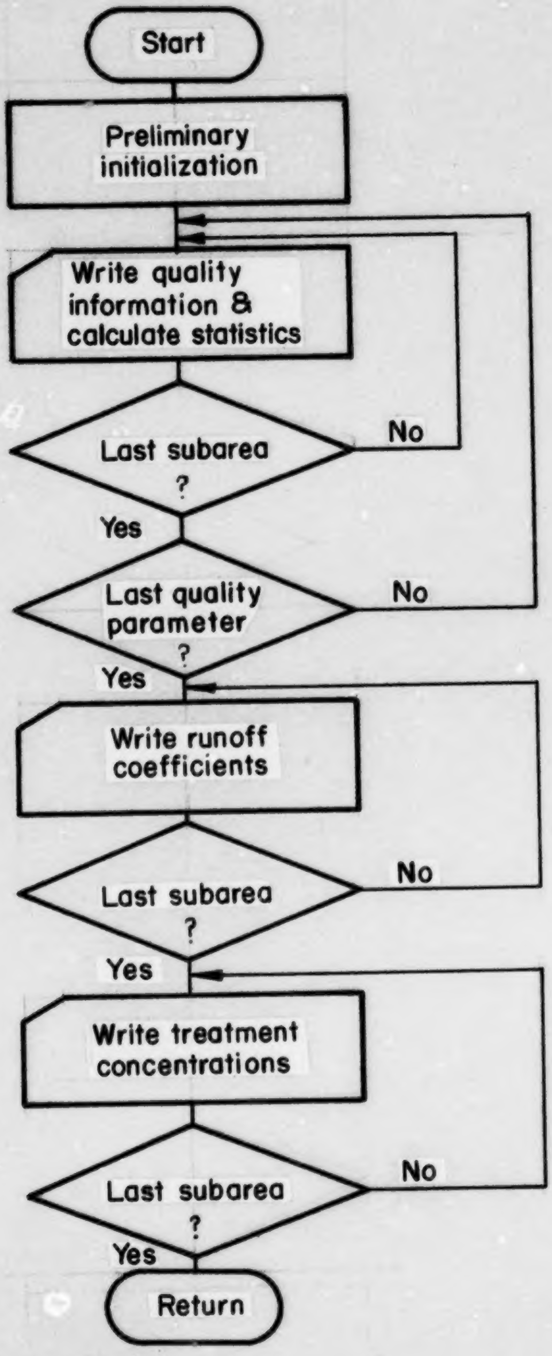
FLOWCHART FOR DATACHK SPARAM SUBROUTINE

Figure A-5


Start
Preliminary initialization
Calculate acreage
Write land use information
Last subarea ?
No
Yes
Return

FLOWCHART FOR DATACHK SLAND SUBROUTINE

Figure A-6



Start
Preliminary initialization
Write quality information & calculate statistics
Last subarea ?
No
Yes
Last quality parameter ?
No
Yes
Write runoff coefficients
Last subarea ?
No
Yes
Write treatment concentrations
Last subarea ?
No
Yes
Return

FLOWCHART FOR DATACHK SQUAL SUBROUTINE

Figure A-7

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

Capabilities of Support Program

Given an ABMAC input data set, DATACHKM will read and initially check the data. All variables are then assigned to one of three subroutines for printing and statistical summary.

Support Program Output

The output from the preprocessing program consists of an initial header page followed by a series of tables. A description of the output from each of the subroutines follows.

The first subroutine (SPARAM) generates three tables containing global parameters, miscellaneous values, and input/output options. The second subroutine (SLAND) examines land uses and corresponding acreages. Totals for each land use as well as each subarea are provided in the land use table. The third subroutine (SQUAL) lists the input concentrations of each pollutant for each subarea. Each pollutant has its own table for clarity and ease of checking. Runoff coefficients and treated withdrawl concentrations are also presented in two subsequent tables. Average of nonzero values, maximums and minimums are provided for all data presented in the third subroutine.

DATA REQUIREMENTS AND SOURCES

The ABMAC model was developed to provide a relatively inexpensive and reasonaby accurate tool for 208 planning with maximum flexibility as to its input data requirements. The establishment of a firm data base is, nevertheless, an important step in the modeling process. Five categories of data are needed as discussed below. Some of these data are essential for model run execution; others are needed for calibration and validation of the model.

System Schematic

The system schematic delineates the configuration of the modeled area, the characteristics of the individual subareas, and the interrelationship between subareas. The important characteristics of a drainage area that must be collected are:

- total surface area
- percent of the area that is impervious
- general soil characteristics as they relate to runoff
- area devoted to various land uses
- population density of the residential areas
- flow conveyance facilities and reservoir data.

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

In general, it is desirable to distinguish within each drainage area three broad land use categories. These are:

A. Natural and protected
B. Nonurbanized but developable
C. Existing Urban

For each of these general land uses, information on the area, population or population density and percent imperviousness is needed for up to six specific land use categories. Typical categories used are:

1. Residential - single family
2. Residential - multiple family
3. Commercial
4. Industrial
5. Open Space
6. Agricultural

Some of the analyses performed with the ABMAC model may utilize future projections of these land uses. The potential sources of land use information are discussed below:

- Federal data sources - many Federal agencies are involved in programs with substantial primary and/or secondary interest in the use of public and private land. Of particular importance might be the National Cooperative Soil Survey Program by Soil Conservation Service (SCS), the National Topographic Map Series and the resource and Land Investigation Programs by both by USGS, and the National Cartographic Information Center (Department of Interior);

- State data sources - the availability of state land use data varies considerably from state to state, but an increasing number of states have developed major land use programs with data readily available;

- Regional/Local data sources - Probably this is the most reliable source of land use data. The main obstacle to overcome might be compatibility of data from various sources within the same study area

Gross Runoff Coefficient

The gross runoff coefficient is defined as total runoff divided by total rainfall. It is needed for each of the broad land use categories selected. It is preferable to estimate this coefficient by comparing rain gage data to monitored runoff data. If data over a full water year are not available, the rain gage data should be compared with runoff monitored during corresponding storms. In general, at least ten storms are needed to provided adequate representation.

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

When extensive monitoring data are available, estimates may be made from land use and drainage basin characteristics. The greater the percentage of impervious surfaces, the greater will be the runoff for a given size storm. Figure A-8 shows the relationship between the percent impervious area and the runoff coefficient that has been developed elsewhere (MERL, 1976). The percentage of impervious area can be developed, from land use data and/or from population density data (see Figure A-9). Typical values are given below.

Land Use Category	Percent Impervious Area	Range of Runoff Coefficient
Residential		
Low Density	20	0.25 - 0.40
Medium Density	40	0.30 - 0.50
High Density	60	0.50 - 0.70
Commercial	80	0.50 - 0.95
Industrial	70	0.60 - 0.90
Institutional, Public	30	0.52 - 0.79
Open, Undeveloped	0	0.10 - 0.30

Rainfall Data

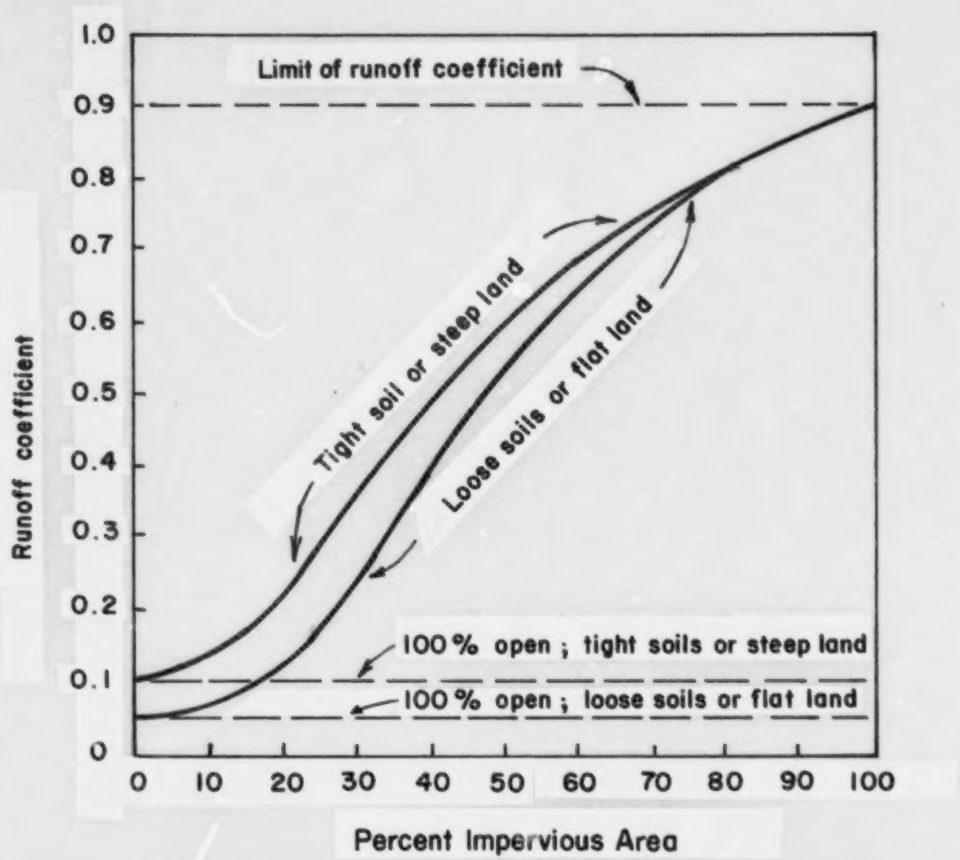
The best source of long-term rainfall data is the National Weather Service (NWS). Data can be obtained from NWS either on tape files or through published daily summaries. In selecting rainfall data it is important to consider areal variability of rainfall for the region in question. If needed local rainfall data sources should be used to supplement the NWS data base.

Hydraulic Data

Information on hydraulic structures within the broad land use categories may be also needed. This includes: (1) data on any reservoirs to determine the change in storage or change in discharge resulting from overflows when reservoir is full, and (2) data on major flow conveyance facilities, which may affect lateral inflows to downstream subareas.

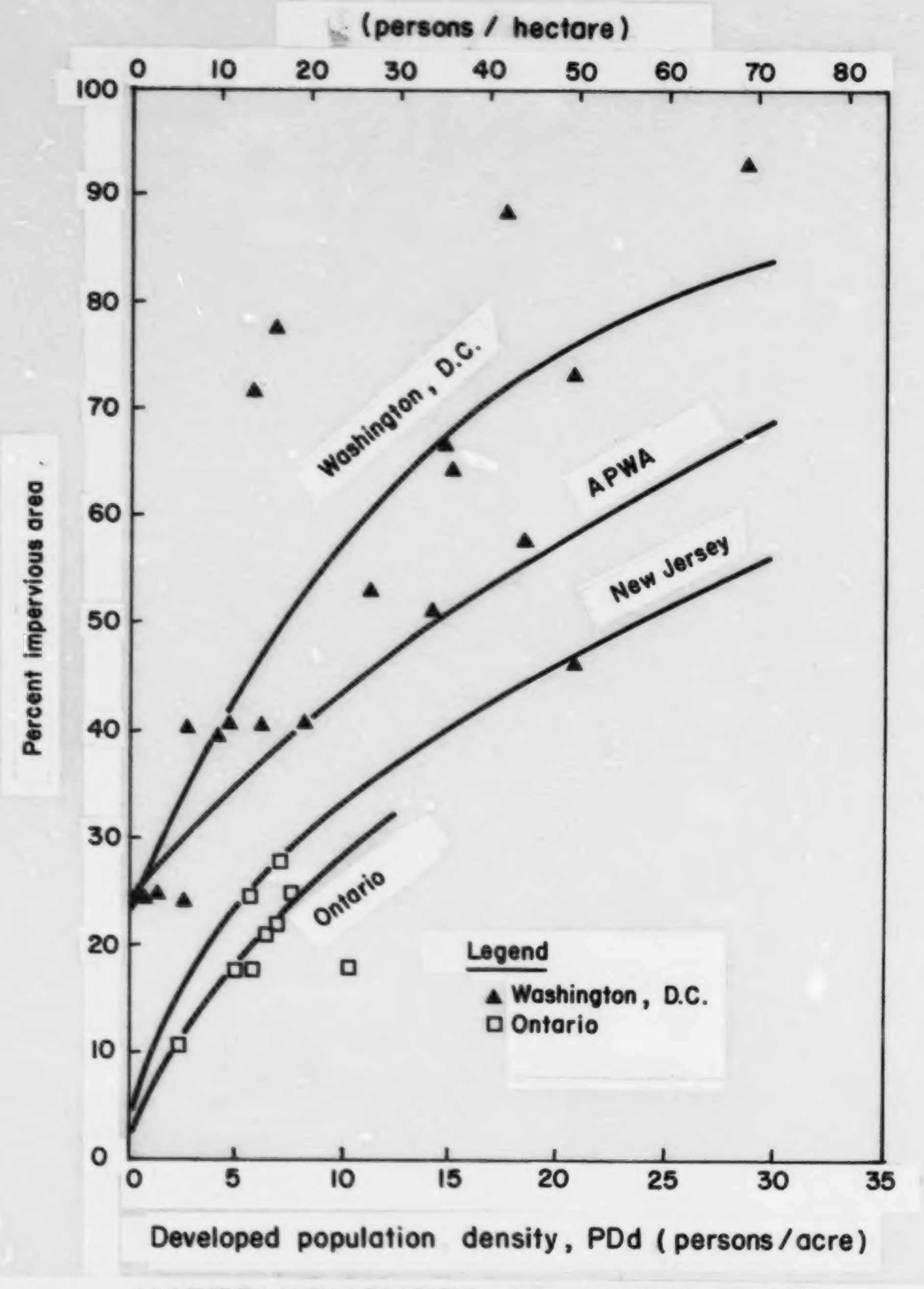
Quality Constituent Concentrations

The selection of concentration values for runoff quality constituents can be approached by either adopting data from national sources, or by local monitoring. Local data are preferred. Typical values from several sources are shown in Tables A-1 through A-3.



DETERMINATION OF RUNOFF COEFFICIENT
FROM LAND USE COVER (MERL, 1976)

Figure A-8



IMPERVIOUSNESS AS A FUNCTION
OF DEVELOPED POPULATION DENSITY

(HEANEY , *et al.*, 1976)

Figure A-9

TABLE A-1. CHARACTERISTIC VALUES FOR URBAN STORMWATER AND COMBINED SEWER OVERFLOW WATER QUALITY

Water Quality Parameter	Combined Sewer Overflow (mg/l)	Urban Stormwater (mg/l)
BOD	100 - 500	11 - 500
TSS	100 - 1500	500 - 11,300
Total Solid	300 - 2000	1000 - 14,600
Organic N	3.5 - 30.1	0.9 - 16
NH_3-N	1.1 - 11.5	0.4 - 2.5
PO_4	1 - 62	10 - 125
Total Coliform	$5x10^4$ - $30x10^6$ MPN/100 ml	$2x10^3$ - $14x10^5$
pH	4.9 - 8.4	*
Fecal Coliform	$5x10^4$ - $11x10^6$ MPN/100 ml	
Chloride		200 - 25,000
Oils		10 - 110
Phenols		0 - 0.2
Lead		0 - 1.9

Source: [1].

TABLE A-2. SUMMARY OF STORMWATER POLLUTANT CONCENTRATIONS

Pollutant	Separate Drainage Areas (a)		Combined Areas (b)	
	Mean	Standard Deviation	Mean	Standard Deviation
BOD	27	25	108	36
COD	205	118	284	110
SS	608	616	372	275
Total Coliform	$3x10^5$	-	$6x10^6$	-
Total Nitrogen (as N)	2.3	1.4	9	6
Total Phosphorus (as P)	0.5	0.4	2.8	2.9

(a) Summary of 20 cities, storm sewers and unsewered areas
(b) Summary of 25 cities, combined sewer areas
(c) All units mg/l except coliforms, MPN/100 ml
(d) Geometric mean

Source: [3].

TABLE A-3. COMPARISON OF STORM SEWER DISCHARGE QUALITY FOR VARIOUS CITIES

Type of wastewater, location, year, Ref. No.	BOD5, mg/l		COD, mg/l		DO, mg/l	SS, mg/l		Total coliforms, MPN/100 ml		Total nitrogen, mg/l as N	Total phosphorus, mg/l as P
	Avg	Range	Avg	Range	Avg	Avg	Range	Avg	Range	Avg	Avg
Typical untreated municipal	200	100-300	500	250-750	--	200	100-350	5×10^7	1×10^7-1×10^9	40	10
Typical treated municipal											
Primary effluent	135	70-200	330	165-500	--	80	40-120	2×10^7	5×10^6-5×10^8	35	7.5
Secondary effluent	25	15-45	55	25-80	--	15	10-30	1×10^3	1×10^2-1×10^4	30	5.0
Storm sewer discharges											
Ann Arbor, Mich., 1965	28	11-62	--	--	--	2,080	650-11,900	--	--	3.5	1.7
Castro Valley, Calif., 1971-72	14	4-37	--	--	8.4	--	--	2×10^4	4×10^3-6×10^4	1.9[b]	--
Des Moines, Iowa, 1969	36	12-100	--	--	--	505	95-1,053	--	--	2.2	0.87
Durham, N.C., 1968	31	2-232	224	40-660	--	--	--	3×10^5	3×10^3-2×10^6[c]	--	0.18
Los Angeles, Calif., 1967-68	9.4	--	--	--	6.9	1,013	--	--	3×10^3-2×10^6	--	--
Madison, Wis., 1970-71	--	--	--	--	--	81	10-1,000	--	--	4.8	1.1
New Orleans, La., 1967-69[d]	12	--	--	--	4.5	26	--	1×10^6	7×10^3-7×10^8	--	--
Roanoke, Va., 1969	7	--	--	--	--	30	--	--	--	--	--
Sacramento, Calif., 1968-69	106	24-283	58	21-176	--	71	3-211	8×10^5	2×10^4-1×10^7[c]	--	--
Tulsa, Okla., 1968-69	11	1-39	85	12-405	--	247	84-2,052	1×10^5	1×10^3-5×10^8	0.3-1.5[e]	0.2-1.2[f]
Washington, D.C., 1969	19	3-90	335	29-1,514	--	1,697	130-11,280	6×10^5	1×10^5-3×10^6	2.1	0.4

b. Only ammonia plus nitrate.
c. Only fecal.
d. Median values from 1 sampling station.
e. Only organic (Kjeldahl) nitrogen.
f. Only soluble orthophosphate.

Source: [4].

INITIAL SYSTEM SETUP REQUIREMENTS

Computer and minicomputer systems vary in syntax and ability to handle external files. Because of this variability, a program desired to be compatible with a wide variety of systems cannot be tailored to a specific system. Consequently, ABMAC and DATACHKM have been kept sufficiently general to allow wide compatibility. Comments have been added where minicomputer users will most commonly add code to manipulate files properly. Hence, initially a programmer familiar with system file handling syntax will need to examine the code and insert appropriate commands. The following discussion is meant as an aid to this individual, highlighting the major aspects to investigate. Once this step is accomplished the regular user need not be concerned with file handling at this level.

System requirements for utilizing ABMAC and DATACHKM are a tape drive (or card reader) to obtain the source code and then a disk and printer for actual runs. In addition, DATACHKM requires the ability to open two input files from disk, one for input data and the other for rainfall. ABMAC has more extensive requirements in that five disk files must be open simultaneously. The five files are, one for lateral inflow, one for input rainfall, one for input data and two for output. Locations of external file access are shown in Figures A-2 to A-7 for both ABMAC and DATACHKM. If possible on a mini-system, it is desirable to designated an output file for use as an input file in the same run.

Since some systems open and close files by statements within the Fortran code, comments have been added to both programs to aid in locating these statements. These comments can be easily spotted by looking for lines with "C" in column 1. Depending on the particular system syntax, some of these locations may not need attention. System users should take note that additional Fortran statements may be needed when file open and close statements are added. For example, when output files are not being used, jumps around open and close statements may be required.

In addition to opening and closing files the programmer should check the logical unit number assignments at the beginning of the programs and modify these values as required to be consistent with the system defined units.

Another area to be checked is the memory requirement of both programs. Typical memory requirements are discussed in a later section in this Users Manual. DATACHKM has extensive array requirements so the number of subareas allowable per run will be limited by the system and should be determined (perhaps 25 - 40 subareas). If overlays or other system modifications are carried out which increase the allowable number of subareas, appropriate values must be inserted in array definition statements and the preliminary initalization code. The user must be aware of this limitation.

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
CENTER OF PAGE
TOP OF IMAGE AREA

Other statements to check for compatibility are: RETURN at the end of the MAIN program segment rather than CALL EXIT, and REWIND rather than close statements.

DROPPED HEAD; BEGIN SECTIONS HERE

MODEL INPUT AND OUTPUT

The first requirement of the user is a basic knowledge of how to access and execute the program as adapted to his computer system. Second, the user needs to be familiar with the process of naming and retrieving the files which will be generated. Lastly, the user must know how to prepare the input data set.

The first two requirements are very system specific and are not appropriately addressed here. The user should seek help from system operators or others. The third requirement however, is discussed in detail in the following section. A flow chart is provided in Figure A-10 as a visual aid and checklist to assist the user in obtaining the desired end product.

Preparing the input data set falls in two broad categories; first, collecting the data and, second, selecting the described options. Collecting data involves compiling the rainfall history, land use types and acreages, runoff coefficients, typical pollutant concentration characteristics, rain factors, subarea and watershed names, storage and withdrawal rates, etc. Once data are collected they must then be placed in proper card format as illustrated in Figure A-11. The same position information is also presented in Table A-4 with correlated variable names and descriptions. Complete variable lists appear in Appendix B to aid the user in definition of variables.

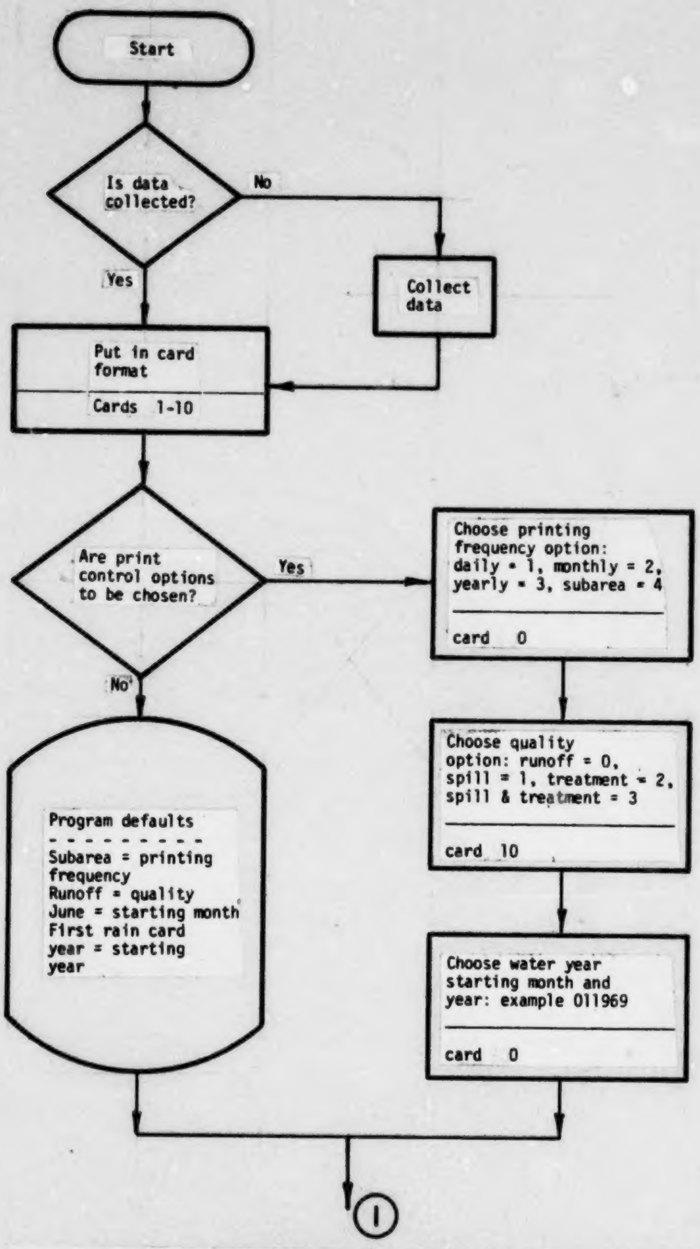
Once subarea input data have been prepared the remaining variables and options need to be chosen. These are specified on input lines number 00 and 10 (at this point all information for lines 01 though 09 and line 10, columns 20-56 should be ready). The remaining variables can be grouped in three categories: 1) printer output options, 2) external input and output flow options, and 3) primary input and rainfall options.

The first category of options involves printer output. Options consist of assigning values for printing frequency, output format, and water year starting month and year. If values are not chosen (i.e., left blank) default values will be in effect. All choices available are illustrated in Figure A-10.

The second category of options involves transfers of flow. External input/output file options have defaults of zero (i.e., no files containing lateral flows or outflows, unless specified.) Refer to Figure A-10 for choices available.

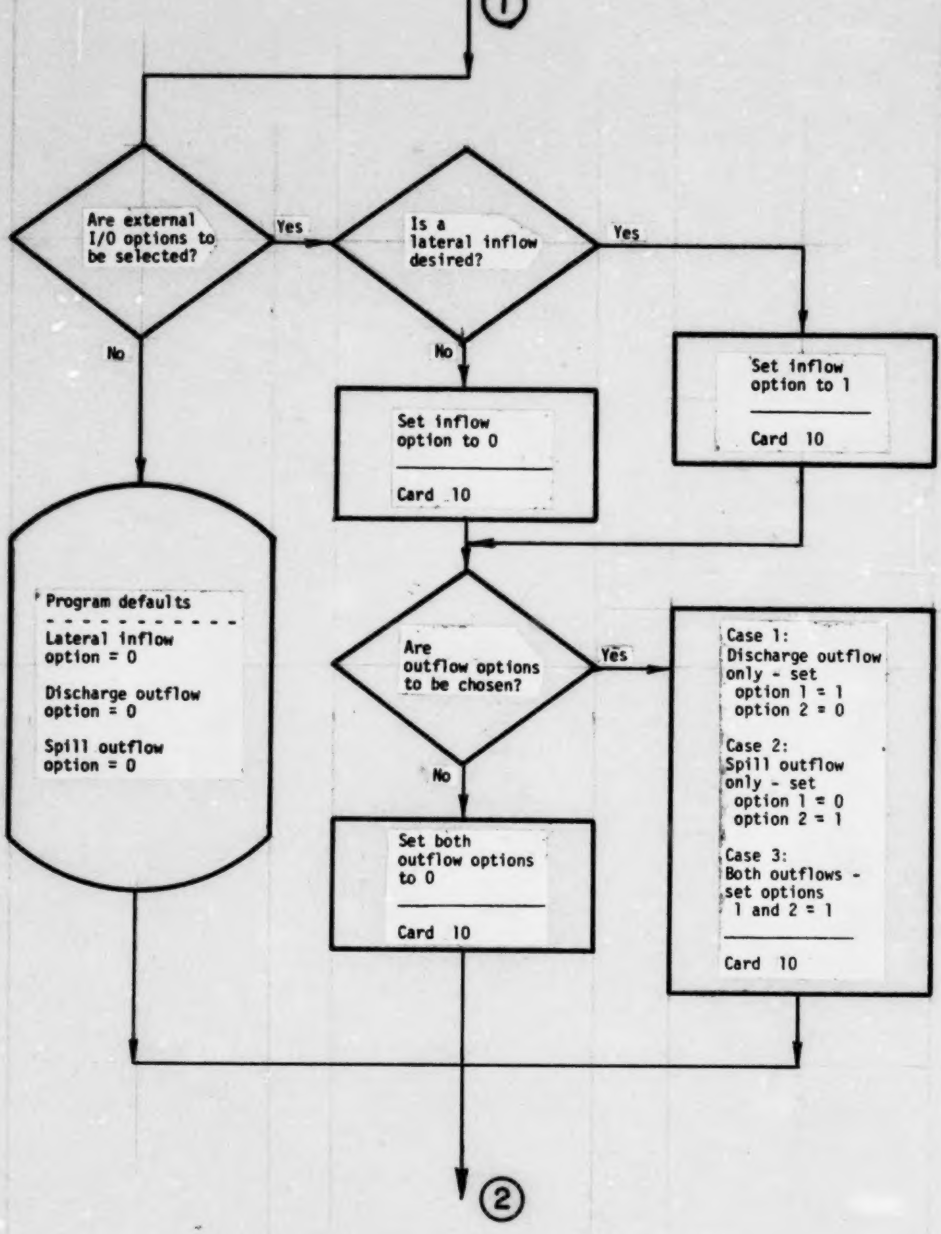
BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)


Start
Is data collected?
No
Yes
Collect data
Put in card format
Cards 1-10
Are print control options to be chosen?
Yes
No
Choose printing frequency option: daily = 1, monthly = 2, yearly = 3, subarea = 4
card 0
Choose quality option: runoff = 0, spill = 1, treatment = 2, spill & treatment = 3
card 10
Choose water year starting month and year: example 011969
card 0
Program defaults
- - - - - - - - -
Subarea = printing frequency
Runoff = quality
June = starting month
First rain card year = starting year
①

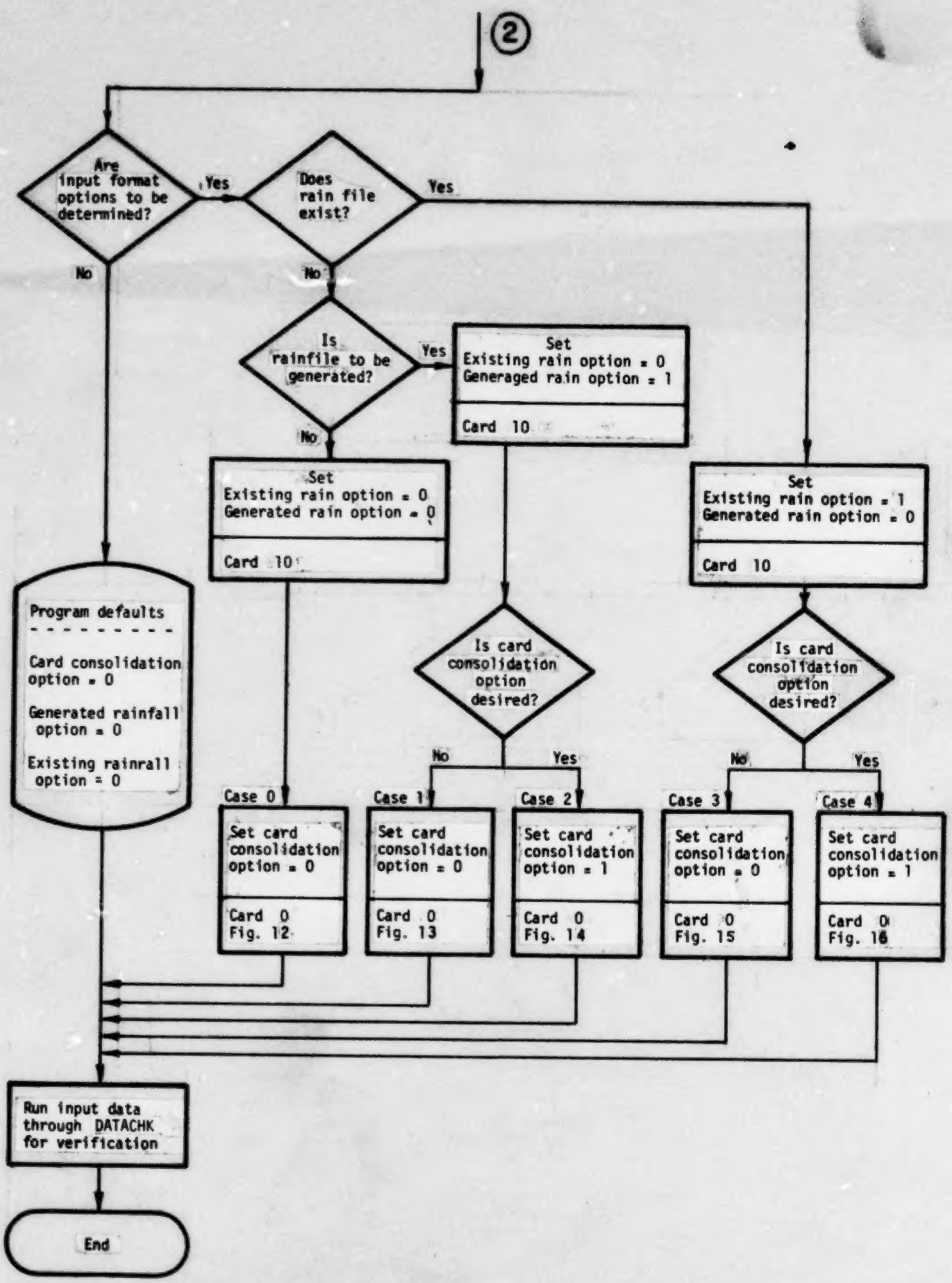
ABMAC MODEL INPUT CARD PARAMETERS USER DECISION TREE

Figure A-10


①
Are external I/O options to be selected?
Yes
No
Is a lateral inflow desired?
Yes
No
Set inflow option to 0
Card 10
Set inflow option to 1
Card 10
Program defaults
Lateral inflow option = 0
Discharge outflow option = 0
Spill outflow option = 0
Are outflow options to be chosen?
Yes
No
Set both outflow options to 0
Card 10
Case 1:
Discharge outflow only - set
option 1 = 1
option 2 = 0
Case 2:
Spill outflow only - set
option 1 = 0
option 2 = 1
Case 3:
Both outflows - set options
1 and 2 = 1
Card 10
②

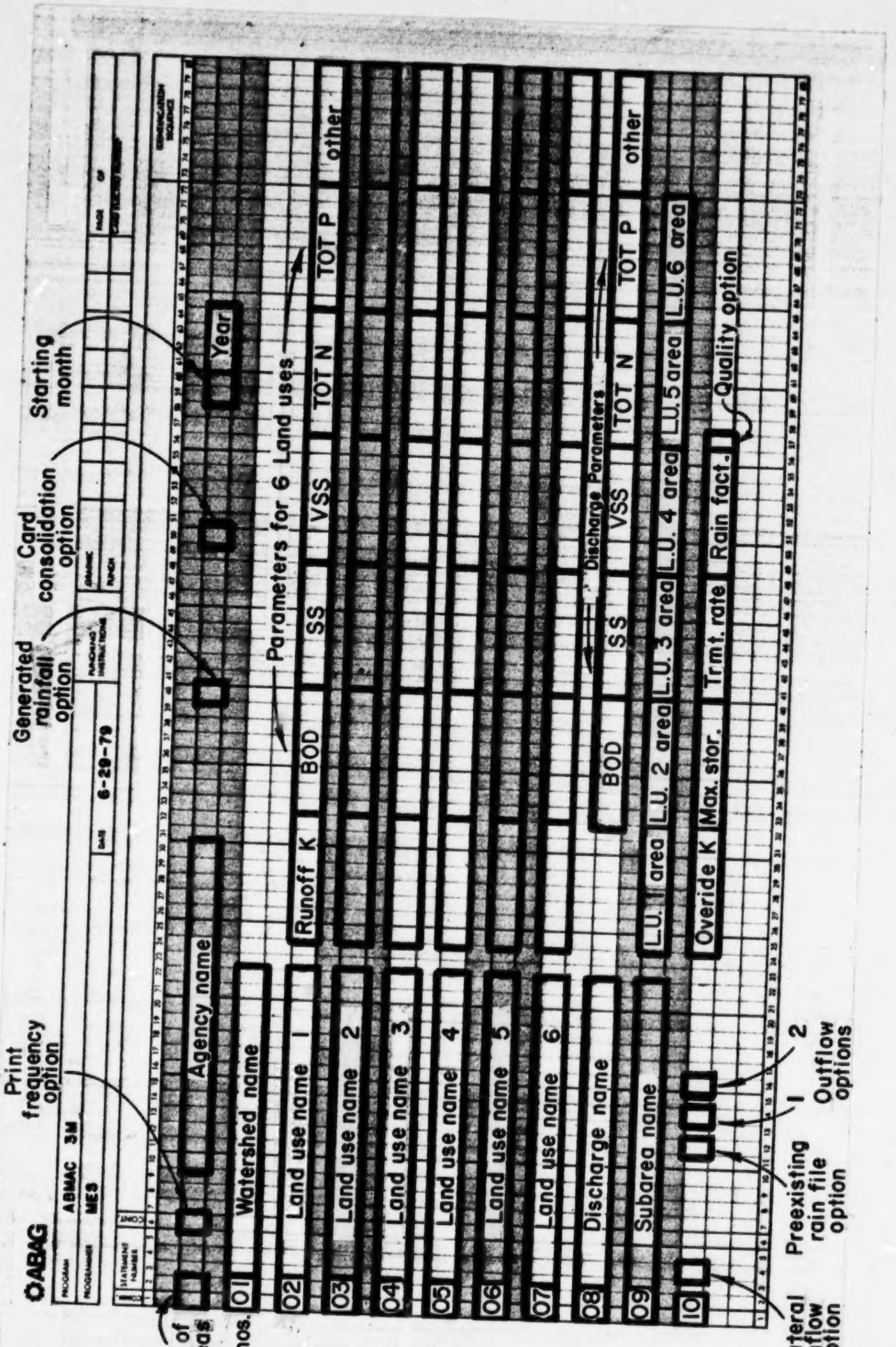
ABMAC MODEL INPUT CARD PARAMETERS USER DECISION TREE

Figure A-10 (cont.)


②
Are input format options to be determined?
Yes
No
Does rain file exist?
Yes
No
Is rainfile to be generated?
Yes
No
Set
Existing rain option = 0
Generaged rain option = 1
Card 10
Set
Existing rain option = 0
Generated rain option = 0
Card 10
Set
Existing rain option = 1
Generated rain option = 0
Card 10
Program defaults
Card consolidation option = 0
Generated rainfall option = 0
Existing rainrall option = 0
Is card consolidation option desired?
No
Yes
Is card consolidation option desired?
No
Yes
Case 0
Set card consolidation option = 0
Card 0
Fig. 12
Case 1
Set card consolidation option = 0
Card 0
Fig. 13
Case 2
Set card consolidation option = 1
Card 0
Fig. 14
Case 3
Set card consolidation option = 0
Card 0
Fig. 15
Case 4
Set card consolidation option = 1
Card 0
Fig. 16
Run input data through DATACHK for verification
End

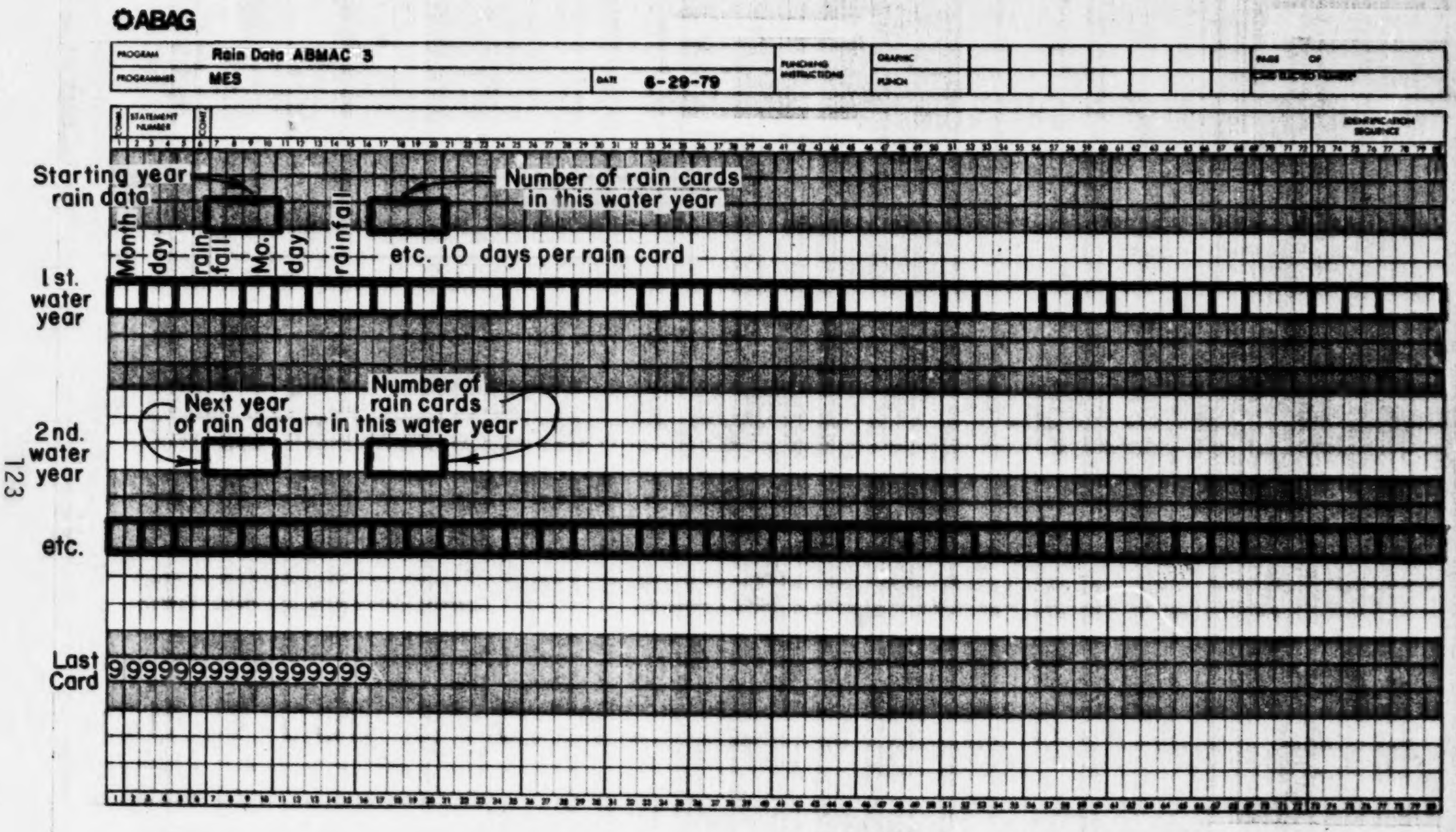
ABMAC MODEL INPUT CARD
PARAMETERS USER DECISION TREE

Figure A-10 (concl.)


ABAG
PROGRAM ABMAC 3M
PROGRAMMER MES
DATE 6-29-79
No. of subareas
Print frequency option
Agency name
Generated rainfall option
Card consolidation option
Starting month
Year
Card nos.
01
Watershed name
02
Land use name 1
Runoff K
BOD
SS
VSS
TOT N
TOT P
other
Parameters for 6 Land uses
03
Land use name 2
04
Land use name 3
05
Land use name 4
06
Land use name 5
07
Land use name 6
08
Discharge name
Discharge Parameters
BOD
SS
VSS
TOT N
TOT P
other
09
Subarea name
L.U. 1 area
L.U. 2 area
L.U. 3 area
L.U. 4 area
L.U. 5 area
L.U. 6 area
10
Overide K
Max. stor.
Trmt. rate
Rain fact.
Quality option
Lateral inflow option
Preexisting rain file option
1
2
Outflow options

ABMAC MODEL INPUT

Figure A-11



ABAG

PROGRAM: Rain Data ABMAC 3

PROGRAMMER: MES

DATE: 6-29-79

Starting year rain data
Number of rain cards in this water year
Month
day
rain fall
Mo.
day
rainfall
etc. 10 days per rain card
1st. water year
Next year of rain data
Number of rain cards in this water year
2nd. water year
etc.
Last Card
9999999999999999

ABMAC MODEL INPUT

Figure A- 11 (concl.)

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
DROPPED HEAD; BEGIN SECTIONS HERE
CENTER OF PAGE
TOP OF IMAGE AREA

TABLE A-4. CARD INPUT SEQUENCE FOR ABMAC

CARD NUMBER	FORMAT	CARD COLUMNS	DESCRIPTION		VARIABLE NAME
00	I2	1-2	Number of Subareas		NSUBS
	I4	3-6	Printing option (Day, Mo., Year)		IPRINT
	5A4	11-30	Agency Name		CLIENT
	I2	39-40	Flag if Rainfile to be created		NINFLG
	I2	49-50	Card Consolidation Option		NCRD
	I2	59-60	Water Year starting month		MSTART
	I4	61-64	Water Year starting year		YSTART
01	I2	1-2	Card Number		NSBCRD
	5A4	3-22	Watershed Name		WASHED
02 thru 07	I2	1-2	Card Number		NSBCRD
	5A4	3-22	Description of land use		AUSE
	7F8.2	25-32	Gross runoff coefficient		QC(x,1)
		33-40	BOD	mg/l	QC(x,2)
		41-48	Suspended Solids	mg/l	QC(x,3)
		49-56	Volatile Suspended Solids	mg/l	QC(x,4)
		57-64	Total Nitrogen	mg/l	QC(x,5)
		65-72	Total Phosphorus	mg/l	QC(x,6)
		73-80	Other parameter	mg/l	QC(x,7)
					x=2 to 8
08	I2	1-2	Card Number		NSBCRD
	5A4	3-22	Discharge Name		AUSE(7)
		33-40	BOD	mg/l	QC(7,1)
		41-48	Suspended Solids	mg/l	QC(7,2)
		49-56	Volatile Suspended Solids	mg/l	QC(7,3)
		57-64	Total Nitrogen	mg/l	QC(7,4)
		65-72	Total Phosphorus	mg/l	QC(7,5)
		73-80	Other Parameter	mg/l	QC(7,6)
09	I2	1-2	Card Number		NSRBCRD
	5A4	3-22	Subarea Name		WNAME
	7F8.2	25-32	Residential	acres	AREA(1)
		33-40	Multifamily Residential	acres	AREA(2)
		41-48	Commercial	acres	AREA(3)
		49-56	Industrial	acres	AREA(4)
		57-64	Open Space	acres	AREA(5)
		65-72	Agricultural	acres	AREA(6)
		73-80	-		-

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"
PAGE NUMBER
EPA-287 (Cin.)
(4-76)

TYPING GUIDE SHEET
BEGIN FIRST LINE OF TEXT HERE
DROPPED HEAD: BEGIN SECTIONS HERE
CENTER OF PAGE
TOP OF IMAGE AREA

10	I2	1-2	Card Number	NSBCRD
	I2	3-4	Flag for lateral inflow	N1FLG
	I2	11-12	Flag for existing Rainfile	N5FLG
	I2	13-14	Flag for Treated Output file	N6FLG
	I2	15-16	Flag for Overflow Output file	N7FLG
	4F8.2	25-32	Gross runoff coefficient override	AKOVER
		33-40	Available wet weather storage mg	STMAX
		41-48	Wet weather treatment capacity mgd	TRRATE
		49-56	Rain factor	RFAC
	I1	57	Quality option of printout	IQUAL
			99 signals end of subarea input	
1.	I4	7-10	Calendar Year	YDATA
	I4	17-20	Number of Raincards for year	NCARD
2.	10(2I2, F4,2)	1-8	First date and quantity of rainfall	
	I2	1-2	First Month	IMDATA(1)
	I2	3-4	Day	IDDATA(1)
	F4,2	5-8	Rain Quantity 100th of an inch	ARAIN(1)
		9-16	Second date and quantity of rainfall	
	I2	9-10	Month	IMDATA(2)
	I2	11-12	Day	IDDATA(2)
	F4.2	13-16	Rain Quantity 100th of an inch	ARAIN(2)
	I2	73-74		IMDATA(10)
	I2	75-76		IDDATA(10)
	F4.2	77-80		ARAIN(10)
repeat 1 & 2 for all years and rain data				
3. LAST CARD			999999999999999999999 signals end of rain data all years. 21 "9's"	

---

a. These are the expected treatment facility concentrations specified for effluent quality.

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA, OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"
PAGE NUMBER
EPA-287 (Cin.)
(4-76)

In a run all three external files can be specified only once. If desired, all three can be utilized by one subarea, or a maximum of three different subareas may each access one of the three external files. Any of the output files generated earlier in a run can be used as a lateral inflow file in the same run, if the minicomputer system being used does not impose a constraint. It may be the case that the run must be split so the previous output file can be renamed as the lateral inflow file for the second part of the run. If so, be sure to calculate the real total run summary from both of the smaller run summaries. (Note to user, discuss this option with the programmer who sets ABMAC up on the system to ensure maximum flexibility).

The third category of input options provides for flexibility in the size of the input data set. If desired the full card decks of input data used in an earlier version of MAC [Metcalf & Eddy, Inc., 1978] can still be processed by ABMAC. However, the size of the input data set can be greatly reduced by use of the card consolidation option and ability to access rainfall files on disk. The ability exists to generate a rainfall file on disk from card input. Consequently, the subsequent runs do not need to contain rain data in the input data stream. Refer to Figure A-10 for full range of choices available.

The card consolidation option reduces the number of input lines by eliminating the need for repeating identical lines. The most common contents of lines (cards) 02 through 10 (see Table A-4) can be placed at the beginning of the data set to be used as a reference. The reference information is then accessed if that line number is missing in any subsequent subarea. Only the first line and lines different from the reference set need appear for each subarea. Figure A-11 provides a complete, self explanatory description of ABMAC input.

The card consolidation option in conjunction with a pre-existing rainfall file will generally result in the smallest input data set. However, if the card consolidation option is chosen, the input data set must be on a disk file rather than cardreader input. Another item to remember is that a line containing "99" in columns 1 & 2 is required to signal the end of the input data if the card consolidation is chosen. Nines also must appear at the end of external files and rainfiles for proper execution of ABMAC. Figures A-12 through A-16 are diagrams of the input data set configurations, highlighting the end of input data (nines) and other requirements.

The output of ABMAC is shown in Figure A-17. The output shown includes the following information:

- o summary of initial input data (run control cards). These include the number of subareas used, printing option in effect, rainfall input option and card consolidation option
- o monthly summary data for an individual subarea. Information shown includes number of rainy days in each month total runoff and pollutant loads

GLOBAL LINE

```
 3   1    ASSOC. BAYAREA GOVTS.          0
```

SUBAREA INPUT

```
BERKELEY
RESIDENTIAL              .43     14.6    296.1   172.2   9.81    .62
RESIDENTIAL MULTI
COMMERCIAL               .86     41.5    288.1   181.7   3.84    .98
INDUSTRIAL               .57     15.8    377.6   186.8   3.58    .91
OPEN                     .2      .21     5.      4.8     .11     .02
AGRICULTURE
TREATED
BERKELEY-C-X             7405.           2667.   2340.   3860.
 0       0 0 0           0.      0.      0.      1.      0       0
```

RAIN INPUT

```
      1969         6
1010   71014   51015 2011016   611 5  7511 6   512 8  511210  211211   61212  20
1213   21218   51219  971220 1551221 1151223   81224 1421225  35 1 8  36 1 9  53
 110   6 111  28 113  56 114 190 115  74 116  74 117   2 119  15 120 151 121 148
 122   5 123  33 124   1 127  48 130   4 2 1   5 2 9  15 212  23 213  50 216  33
 217   5 227  15 228  69 3 1  18 3 4 110 3 7  18 3 8   2 3 9  15 314   4 413   3
 418   2 426   5 6 8  65 6 9  22
      1970         7
1018   31020  311021   61022  101023  3011 3  6711 4  2611 5  4211 6  3411 7   4
11 9   21111  261124  911125  381127  341128 1841129  971130  3212 1  3012 2  44
12 3  6612 4 16812 7  1012 8  101213  201215  541216  501217  281218  361220  50
1221  221225   41226  381227  261229  281230  26 1 1  16 110   8 111  38 112  42
 113  16 114  10 115   4 117   2 2 2   1 216  10 218  42 227   8 312  76 314  50
 316   3 323  22 325  50 326 101 4 7   2 410  14 414  28 417  14 420   3 5 1   3
 5 2   2 5 4   2 513   2 527   2
99999999999999999
```

SUBAREA INPUT

```
LAKE MERRITT
RESIDENTIAL              .43     14.6    296.1   172.2   9.01    .62
RESIDENTIAL MULTI
COMMERCIAL               .86     41.5    288.1   181.7   3.84    .98
INDUSTRIAL               .57     15.8    377.6   186.8   3.58    .91
OPEN                     .2      .21     5.      4.8     .11     .02
AGRICULTURE
TREATED
LAKE MERRITT-C-X         7879.           2567.   4216.   251.
 0       0 0 0           0.      0.      0.      1.      0       0
```

RAIN INPUT

```
      1969         6
1010   71014   51015 2011016   611 5  7511 6   512 8  511210  211211   61212  20
1213   21218   51219  971220 1551221 1151223   81224 1421225  35 1 8  36 1 9  53
 118   6 111  28 113  56 114 190 115  74 116  74 117   2 119  15 120 151 121 148
 122   5 123  33 124   1 127  48 130   4 2 1   5 2 9  15 212  23 213  50 216  33
 217   5 227  15 228  69 3 1  18 3 4 110 3 7  18 3 8   2 3 9  15 314   4 413   3
 418   2 426   5 6 8  65 6 9  22
      1970         7
1018   31020  311021   61022  101023  3011 3  6711 4  2611 5  4211 6  3411 7   4
11 9   21111  261124  911125  381127  341128 1841129  971130  3212 1  3012 2  44
12 3  6612 4 16812 7  1012 8  101213  201215  541216  501217  281218  361220  50
1221  221225   41226  381227  261229  281230  26 1 1  16 110   8 111  38 112  42
 113  16 114  10 115   4 117   2 2 2   1 216  10 218  42 227   8 312  76 314  50
 316   3 323  22 325  50 326 101 4 7   2 410  14 414  28 417  14 420   3 5 1   3
 5 2   2 5 4   2 513   2 527   2
99999999999999999
```

SUBAREA INPUT

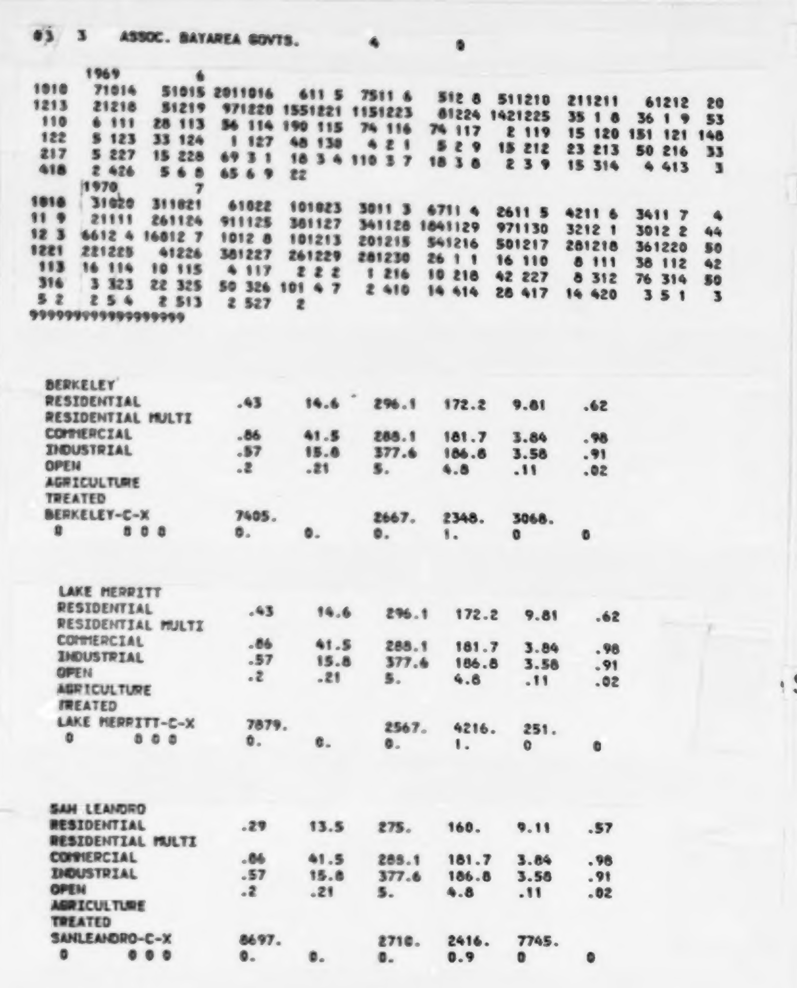
```
SAN LEANDRO
RESIDENTIAL              .29     13.5    275.    160.    9.11    .57
RESIDENTIAL MULTI
COMMERCIAL               .86     41.5    288.1   181.7   3.84    .98
INDUSTRIAL               .57     15.8    377.6   186.8   3.58    .91
OPEN                     .2      .21     5.      4.8     .11     .02
AGRICULTURE
TREATED
SANLEANDRO-C-X           8697.           2710.   2416.   7745.
 0       0 0 0           0.      0.      0.      0.9     0       0
```

RAIN INPUT

```
      1969         6
1010   71014   51015 2011016   611 5  7511 6   512 8  511210  211211   61212  20
1213   21218   51219  971220 1551221 1151223   81224 1421225  35 1 8  36 1 9  53
 110   6 111  28 113  56 114 190 115  74 116  74 117   2 119  15 120 151 121 148
 122   5 123  33 124   1 127  48 130   4 2 1   5 2 9  15 212  23 213  50 216  33
 217   5 227  15 228  69 3 1  18 3 4 110 3 7  18 3 8   2 3 9  15 314   4 413   3
 418   2 426   5 6 8  65 6 9  22
      1970         7
1018   31020  311021   61022  101023  3011 3  6711 4  2611 5  4211 6  3411 7   4
11 9   21111  261124  911125  381127  341128 1841129  971130  3212 1  3012 2  44
12 3  6612 4 16812 7  1012 8  101213  201215  541216  501217  281218  361220  50
1221  221225   41226  381227  261229  281230  26 1 1  16 110   8 111  38 112  42
 113  16 114  10 115   4 117   2 2 2   1 216  10 218  42 227   8 312  76 314  50
 316   3 323  22 325  50 326 101 4 7   2 410  14 414  28 417  14 420   3 5 1   3
 5 2   2 5 4   2 513   2 527   2
99999999999999999
```

EXAMPLE OF ABMAC MODEL INPUT DATA WITHOUT DEFAULT VALUES (NCRD = 0 , NINFLG = 0 , N5FLG = 0)

Figure A-12



```
03  3   ASSOC. BAYAREA GOVTS.         4        0

       1969          6
1010    71014    51015 2011016   611 5  7511 6    512 8  511210  211211    61212  20
1213    21218    51219  971220 1551221 1151223    81224 1421225  35 1 8  36 1 9  53
 110   6 111   28 113  36 114 190 115  74 116  74 117    2 119  15 120 151 121 148
 122   5 123   33 124   1 127  48 130    4 2 1    5 2 9  15 212  23 213  50 216  33
 217   5 227   15 228  69 3 1  18 3 4 110 3 7  18 3 8    2 3 9  15 314   4 413   3
 418   2 426    5 6 8  65 6 9  22
      1970           7
1010    31020   311021   61022  101023  3011 3  6711 4  2611 5  4211 6  3411 7   4
11 9    21111   261124  911125  381127  341128 1841129  971130  3212 1  3012 2  44
12 3  6612 4  16012 7   1012 8  101213  201215  541216  501217  281218  361220  50
1221   221225    41226  381227  261229  281230  26 1 1  16 110   8 111  38 112  42
 113   16 114   10 115   4 117   2 2 2   1 216  10 218  42 227   8 312  76 314  50
 316    3 323   22 325  50 326 101 4 7   2 410  14 414  28 417  14 420   3 5 1   3
 5 2    2 5 4    2 513   2 527   2
9999999999999999999


  BERKELEY
  RESIDENTIAL            .43     14.6    296.1   172.2   9.81    .62
  RESIDENTIAL MULTI
  COMMERCIAL             .86     41.5    288.1   181.7   3.84    .98
  INDUSTRIAL             .57     15.8    377.6   186.8   3.58    .91
  OPEN                   .2      .21     5.      4.8     .11     .02
  AGRICULTURE
  TREATED
  BERKELEY-C-X           7405.           2667.   2348.   3068.
   0       0 0 0         0.      0.      0.      1.      0       0


   LAKE MERRITT
   RESIDENTIAL            .43     14.6    296.1   172.2   9.81    .62
   RESIDENTIAL MULTI
   COMMERCIAL             .86     41.5    288.1   181.7   3.84    .98
   INDUSTRIAL             .57     15.8    377.6   186.8   3.58    .91
   OPEN                   .2      .21     5.      4.8     .11     .02
   AGRICULTURE
   TREATED
   LAKE MERRITT-C-X       7879.           2567.   4216.   251.
    0       0 0 0         0.      0.      0.      1.      0       0


  SAN LEANDRO
  RESIDENTIAL            .29     13.5    275.    160.    9.11    .57
  RESIDENTIAL MULTI
  COMMERCIAL             .86     41.5    288.1   181.7   3.84    .98
  INDUSTRIAL             .57     15.8    377.6   186.8   3.58    .91
  OPEN                   .2      .21     5.      4.8     .11     .02
  AGRICULTURE
  TREATED
  SANLEANDRO-C-X         8697.           2710.   2416.   7745.
   0       0 0 0         0.      0.      0.      0.9     0       0
```

GLOBAL LINE

RAIN INPUT

SUBAREA INPUT

**EXAMPLE OF ABMAC MODEL
INPUT DATA WITH SAME
RAINFALL FOR ALL SUBAREAS
(NCRD = 0 , NINFLG = 1 , N5FLG = 0)**

Figure A-13

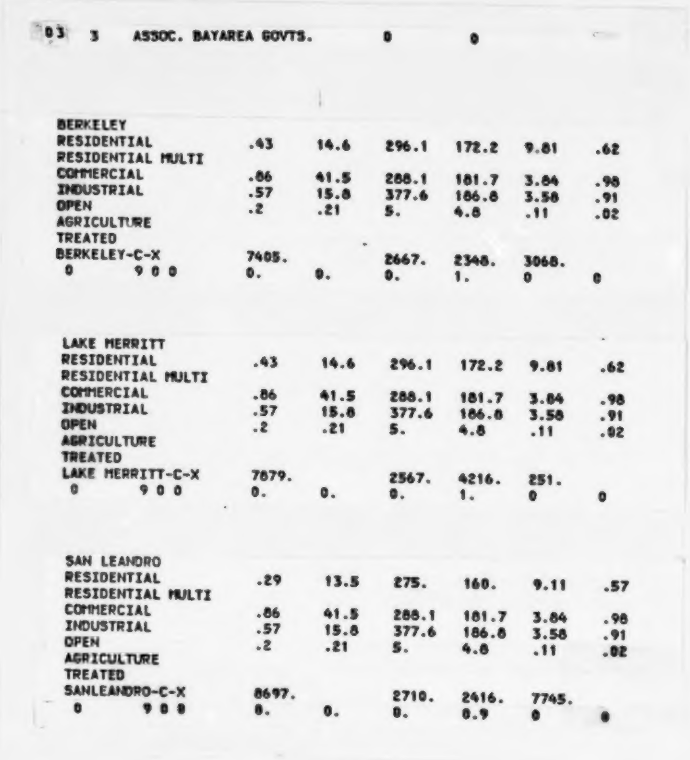
```
03   3   ASSOC. BAYAREA GOVTS.        4        1                                              GLOBAL LINE


02RESIDENTIAL              .43     14.6    296.1   172.2   9.81    .62
03RESIDENTIAL MULTI
04COMMERCIAL               .86     41.5    288.1   181.7   3.84    .98
05INDUSTRIAL               .57     15.8    377.6   186.8   3.58    .91
06OPEN                     .2      .21     5.      4.8     .11     .02                       REFERENCE SET
07AGRICULTURE
08TREATED
09BERKELEY-C-X             7405.           2667.   2348.   3068.
10 0        0 0 0          0.      0.      0.      1.      0       0


      1969         6
1010   71014   51015 2011016   611 5  7511 6   512 8  511210  211211   61212  20
1213   21218   51219  971220 1551221 1151223   81224 1421225  35 1 8  36 1 9  53
 110   6 111  28 113  56 114 198 115  74 116  74 117   2 119  15 120 151 121 148
 122   5 123  33 124   1 127  48 130   4 2 1   5 2 9  15 212  23 213  50 216  33
 217   5 227  15 228  69 3 1  18 3 4 110 3 7  18 3 8   2 3 9  15 314   4 413   3
 418   2 426   5 6 8  65 6 9  22
      1970         7                                                                          RAIN INPUT
1018   31020  311021   61022  101023  3011 3  6711 4  2611 5  4211 6  3411 7   4
11 9   21111  261124  911125  381127  341128 1841129  971130  3212 1  3012 2  44
12 3  6612 4 16812 7  1012 8  101213  201215  541216  501217  281218  361220  50
1221  221225   41226  381227  261229  281230  26 1 1  16 110   8 111  38 112  42
 113  16 114  10 115   4 117   2 2 2   1 216  10 218  42 227   8 312  76 314  50
 316   3 323  22 325  50 326 101 4 7   2 410  14 414  28 417  14 420   3 5 1   3
 5 2   2 5 4   2 513   2 527   2
999999999999999999



01BERKELEY



01LAKE MERRITT
09LAKE MERRITT-C-X         7879.           2567.   4216.   251.                              SUBAREA INPUT 2/



01SAN LEANDRO
02RESIDENTIAL              .29     13.5    275.    160.    9.11    .57
09SANLEANDRO-C-X           8697.           2710.   2416.   7745.
10 0        0 0 0          0.      0.      0.      0.9     0       0



99                                                                                            LAST LINE
```

1/ If NCRD = 1, Data set must be file on system not input card deck.

2/ Only card 01 and cards which differ from reference cards.

EXAMPLE OF ABMAC MODEL
INPUT DATA WITH LAND USE AND
RAINFALL CONSOLIDATION CARD OPTION
NCRD 1/ = 1 , NINFLG = 1 , N5FLG = 0

Figure A-14



```
03  3   ASSOC. BAYAREA GOVTS.       0       0

BERKELEY
RESIDENTIAL              .43    14.6    296.1   172.2   9.81    .62
RESIDENTIAL MULTI
COMMERCIAL               .86    41.5    288.1   181.7   3.84    .98
INDUSTRIAL               .57    15.8    377.6   186.8   3.58    .91
OPEN                     .2     .21     5.      4.8     .11     .02
AGRICULTURE
TREATED
BERKELEY-C-X             7405.          2667.   2348.   3068.
 0        9 0 0          0.     0.      0.      1.      0       0


LAKE MERRITT
RESIDENTIAL              .43    14.6    296.1   172.2   9.81    .62
RESIDENTIAL MULTI
COMMERCIAL               .86    41.5    288.1   181.7   3.84    .98
INDUSTRIAL               .57    15.8    377.6   186.8   3.58    .91
OPEN                     .2     .21     5.      4.8     .11     .02
AGRICULTURE
TREATED
LAKE MERRITT-C-X         7879.          2567.   4216.   251.
 0        9 0 0          0.     0.      0.      1.      0       0


SAN LEANDRO
RESIDENTIAL              .29    13.5    275.    160.    9.11    .57
RESIDENTIAL MULTI
COMMERCIAL               .86    41.5    288.1   181.7   3.84    .98
INDUSTRIAL               .57    15.8    377.6   186.8   3.58    .91
OPEN                     .2     .21     5.      4.8     .11     .02
AGRICULTURE
TREATED
SANLEANDRO-C-X           8697.          2710.   2416.   7745.
 0        9 0 0          0.     0.      0.      0.9     0       0
```

GLOBAL LINE

SUBAREA INPUT

EXAMPLE OF ABMAC MODEL INPUT DATA
FOR MODEL RUN WITH RAINFALL DATA ON FILE
(NCRD = 0 , NINFLG = 0 , N5FLG = 1)

Figure A-15

```
03   3    ASSOC. BAYAREA GOVTS.          0          1                          GLOBAL LINE


02RESIDENTIAL             .43      14.6     296.1    172.2    9.81     .62
03RESIDENTIAL MULTI
04COMMERCIAL              .86      41.5     288.1    181.7    3.84     .98
05INDUSTRIAL              .57      15.8     377.6    186.8    3.58     .91
06OPEN                    .2       .21      5.       4.8      .11      .02     REFERENCE SET
07AGRICULTURE
08TREATED
09BERKELEY-C-X            7405.             2667.    2348.    3068.
10 0         6 0 0        0.       0.       0.       1.       0        0



01BERKELEY


01SAN LEANDRO
02RESIDENTIAL             .29      13.5     275.     160.     9.11     .57
09SANLEANDRO-C-X          8697.             2718.    2416.    7748.            SUBAREA INPUT 2/
10 0         6 0 0        0.       0.       0.       0.9      0        0


01LAKE MERRITT
09LAKE MERRITT-C-X        7879.             2567.    4216.    251.

99                                                                             LAST LINE
```

1/ If NCRD = 1, Data set must be file on system not input card deck.

2/ Only card 01 and cards which differ from reference cards.

EXAMPLE OF ABMAC MODEL INPUT DATA FOR MODEL RUN WITH RAINFALL DATA ON FILE AND LAND USE CONSOLIDATION CARD OPTION (NCRD 1/ = 1 , NINFLG = 0 , N5FLG = 0)

Figure A-16

```
.              INITIAL INPUT DATA
-------------------------------------------------------------

NO. OF SUBAREAS               =  6


PRINTING OPTION IN EFFECT     =  MONTHLY


RAINFALL INPUT OPTION         =  0     (WHEN NOT OVERRIDDEN BY A NONZERO VALUE OF NS)


CARD CONSOLIDATION OPTION     =  1

1970                                        MONTHLY  SUMMARY

                                     LAKE MERRITT             LAKE MERRITT-C-X
------------------------------------------------------------------------------------------------------------------------------
                                                                                             RUNOFF
MONTH RAIN  RAIN   RUNOFF  OVERFLOW  TREATED  OVERFL  TREAT  MAX STORAGE          POLLUTANT LOAD, THOUSANDS OF POUNDS
       IN.  DAYS    MGAL     MGAL     MGAL     DAYS   DAYS       MGAL     ------------------------------------------------------
----  ----  ----  -------  --------  -------  ------  -----  -----------    BOD     SS      VSS    TOT N   TOT P   OTHERS
                                                                           ------- ------- ------- ------- ------- -------

  8   0.00    0      0.0      0.0      0.0  *   0     0.0         0.0*      0.      0.      0.      0.      0.      0.

  9   0.00    0      0.0      0.0      0.0  *   0     0.0         0.0*      0.      0.      0.      0.      0.      0.

 10   0.00    5      1.1      1.1      0.0  *   5     0.0         0.0*      0.      0.      0.      0.      0.      0.

 11   6.77   13      9.2      9.2      0.0  *  13     0.0         0.0*      0.      0.      0.      0.      0.      0.

 12   7.10   18      9.7      9.7      0.0  *  18     0.0         0.0*      0.      0.      0.      0.      0.      0.

  1   1.36    8      1.9      1.9      0.0  *   8     0.0         0.0*      0.      0.      0.      0.      0.      0.

  2   0.61    4      0.8      0.8      0.0  *   4     0.0         0.0*      0.      0.      0.      0.      0.      0.

  3   3.02    6      4.1      4.1      0.0  *   6     0.0         0.0*      0.      0.      0.      0.      0.      0.

  4   0.61    5      0.8      0.8      0.0  *   5     0.0         0.0*      0.      0.      0.      0.      0.      0.

  5   0.11    5      0.1      0.1      0.0  *   5     0.0         0.0*      0.      0.      0.      0.      0.      0.

  6   0.00    0      0.0      0.0      0.0  *   0     0.0         0.0*      0.      0.      0.      0.      0.      0.

  7   0.00    0      0.0      0.0      0.0  *   0     0.0         0.0*      0.      0.      0.      0.      0.      0.
WATER YEAR TOTAL (OR MAX*)

     20.38   64     27.8     27.8      0.0     64     0.0          0.0*      0.      1.      1.      0.      0.      0.


SUBAREA RUN TOTAL (OR MAX*)

     43.97  118     59.9     59.9      0.0    118     0.0          0.0*      0.      3.      2.      0.      0.      0.


          AVERAGE ANNUAL SUBAREA VALUES USING  3  YEARS OF RECORD ---  1968 TO 1970
-------------------------------------------------------------------------------------------

     14.66   39     20.0     20.0      0.0     39     0.0          0.0*      0.      1.      1.      0.      0.      0.


                                           RUN           SUMMARY

               CUMULATIVE AVERAGE ANNUAL VALUES FOR    6 SUBAREAS, USING   3 YEARS OF RECORD ---  1968 TO 1970
---------------------------------------------------------------------------------------------------------------------
                                                                                       OVERFLOW
  RAIN  RAIN   RUNOFF  OVERFLOW  TREATED  OVERFL  TREAT  MAX STORAGE        POLLUTANT LOAD, THOUSANDS OF POUNDS
   IN.  DAYS    MGAL     MGAL     MGAL     DAYS   DAYS       MGAL      ---------------------------------------------------
  ----  ----  -------  --------  -------  ------  -----  -----------     BOD     SS      VSS    TOT N   TOT P   OTHERS
                                                                      ------- ------- ------- ------- ------- -------

 15.15$  39$   5805.1   4477.2   1328.0     -       -         -          646.   9168.   5328.   220.     23.      0.
 $  :  REFERS TO SUBAREA AVERAGE VALUES AS DISTINGUISHED FROM SUBAREA TOTAL VALUES.
```

EXAMPLE OF ABMAC MODEL OUTPUT

Figure A-17

- run summary for all subareas and for the period of record. Information shown is the same as for monthly summaries.

If the input is run through the DATACHK additional printout includes the following (see Figure A-18).

- summary of global parameters
- subarea parameters -- summary for all subareas within the watershed (override coefficient, rain factor, maximum storage, treatment rate, and quality options)
- input/output options for all subareas
- land use acreage for all subares
- pollutant concentrations for all subareas within a watershed summarized by the types of pollutants used
- gross runoff coefficient for all land uses within each subarea
- treated effluent concentration for each quality constituents summarized by subarea

The main utility of the DATACHK option is in large scale model application, where many different watershed and subareas are used, and it is easy to err in the input data stream.

CALIBRATION PROCEDURE

The process of calibration involves comparing model output with data from storms monitored within the study area. Providing that any discrepancies are explainable and reasonable, the coefficients used in the model may be adjusted. Calibration of a model requires an extensive data base due to the well documented variability of stormwater runoff events. Sampling over several rain seasons would be required to truly calibrate a model which is concerned with broad scale runoff effects. Refer to Section 6 of this report for a more detailed discussion.

An important aspect of the calibration process is evaluation of model sensitivity. Since model results depend heavily on runoff coefficients and pollutant concentrations, they need to be carefully chosen. If subregional analyses are being made, runoff flow and quality sampling are needed to fine tune the model. In general, if too small a watershed is being analyzed, small scale models will better approximate watershed characteristics. If the runoff coefficient is off by a factor of two and a pollutant concentration is off by a factor of three, the pollutant load may be off by as much as a factor of six. This multiplicative effect necessitates the careful choice of input parameters.

```
                                        GLOBAL PARAMETERS
----------------------------------------------------------------------
CLIENT                          =       ASSOC BAY AREA GOVTS

NUMBER OF SUBAREAS              =       6

STARTING DATE                   =       0/    0

PRINTING OPTION                 =       3     YEARLY

INPUT CARD CONSOLIDATION        =       0

(CARD READ UNIT NO.)            =       9

(LINE PRINTER UNIT NO.)         =       6
----------------------------------------------------------------------
SUMMARY                                      SUBAREA PARAMETERS

WATERSHED &           OVERRIDE       RAIN        MAXIMUM      TREATMENT        QUALITY  OPTION
SUBAREA NAME         COEFFICIENT     FACTOR      STORAGE        RATE        NUMBER            NAME
                                                 MGAL/D        MGAL/D
--------------------  ------------  ------------  ------------  ------------  ------------  --------------------

BERKELEY                    0.00          1.00           0.            0.            0.          RUNOFF
BERKELEY-C-X

LAKE MERRITT                0.00          1.10           0.            0.            0.          RUNOFF
LAKE MERRITT-A-X

LAKE MERRITT                0.00          1.00           0.            0.            0.          RUNOFF
LAKE MERRITT-C-X

SAN LEANDRO                 0.00          1.20        1000.           10.            3.   OVERFLOW + TREATMENT
SAN LEANDRO-A-X

SAN LEANDRO                 0.00          1.00           0.            0.            0.          RUNOFF
SAN LEANDRO-B-X

SAN LEANDRO                 0.00          0.90           0.            0.            0.          RUNOFF
SANLEANDRO-C-X


--------------------  ------------  ------------  ------------  ------------  ------------  --------------------
                                         INPUT / OUTPUT OPTIONS


WATERSHED &            LATERAL       EXISTING      GENERATED       TREATED      OVERFLOW
SUBAREA NAME          INFLOW FILE    RAIN FILE     RAIN FILE    OUTFLOW FILE  OUTFLOW FILE
--------------------  ------------  ------------  ------------  ------------  ------------
BERKELEY                     0.            0.            0.            0.            0.
BERKELEY-C-X

LAKE MERRITT                 0.            0.            0.            0.            0.
LAKE MERRITT-A-X

LAKE MERRITT                 0.            0.            0.            0.            0.
LAKE MERRITT-C-X

SAN LEANDRO                  0.            0.            0.            0.            0.
SAN LEANDRO-A-X

SAN LEANDRO                  0.            0.            0.            0.            0.
SAN LEANDRO-B-X

SAN LEANDRO                  0.            0.            0.            0.            0.
SANLEANDRO-C-X

--------------------  ------------  ------------  ------------  ------------  ------------
```

EXAMPLE OF DATACHK PROGRAM OUTPUT

Figure A-18

```
SUMMARY                            SURFACE RUNOFF POLLUTANT CONCENTRATION           BIOCHEMICAL OXYGEN DEMAND
                                              ----- MG/L -----

WATERSHED &             LAND USE 1     LAND USE 2     LAND USE 3     LAND USE 4     LAND USE 5     LAND USE 6
SUBAREA NAME
--------------------   ------------   ------------   ------------   ------------   ------------   ------------
BERKELEY               RESI   14.60   RESI    0.00   COMM   41.50   INDU   15.80   OPEN    0.21   AGRI    0.00
BERKELEY-C-X

LAKE MERRITT           RESI    0.00   RESI    0.00   COMM    0.00   INDU    0.00   OPEN    0.21   AGRI    0.00
LAKE MERRITT-A-X

LAKE MERRITT           RESI   14.60   RESI    0.00   COMM   41.50   INDU   15.80   OPEN    0.21   AGRI    0.00
LAKE MERRITT-C-X

SAN LEANDRO            RESI    0.00   RESI    0.00   COMM    0.00   INDU    0.00   OPEN    0.21   AGRI    0.00
SAN LEANDRO-A-X

SAN LEANDRO            RESI    0.00   RESI    0.00   COMM    0.00   INDU    0.00   OPEN    0.21   AGRI    0.00
SAN LEANDRO-B-X

SAN LEANDRO            RESI   13.50   RESI    0.00   COMM   41.50   INDU   15.80   OPEN    0.21   AGRI    0.00
SANLEANDRO-C-X

--------------------   ------------   ------------   ------------   ------------   ------------   ------------
    AVERAGE-NONZERO           14.23           0.00          41.50          15.80           0.21           0.00
    MAXIMUM                   14.60           0.00          41.50          15.80           0.21           0.00
    MINIMUM                    0.00           0.00           0.00           0.00           0.21           0.00
```

```
SUMMARY                                              LAND USE ACREAGE
                                                     ----- ACRES -----

WATERSHED &             LAND USE 1     LAND USE 2     LAND USE 3     LAND USE 4     LAND USE 5     LAND USE 6      TOTAL
SUBAREA NAME                                                                                                      ACRES
--------------------   ------------   ------------   ------------   ------------   ------------   ------------   --------
BERKELEY               RESI   7405.   RESI      0.   COMM   2667.   INDU   2348.   OPEN   3068.   AGRI      0.     15488.
BERKELEY-C-X

LAKE MERRITT           RESI      0.   RESI      0.   COMM      0.   INDU      0.   OPEN    377.   AGRI      0.       377.
LAKE MERRITT-A-X

LAKE MERRITT           RESI   7879.   RESI      0.   COMM   2567.   INDU   4216.   OPEN    251.   AGRI      0.     14913.
LAKE MERRITT-C-X

SAN LEANDRO            RESI      0.   RESI      0.   COMM      0.   INDU      0.   OPEN  13902.   AGRI      0.     13902.
SAN LEANDRO-A-X

SAN LEANDRO            RESI      0.   RESI      0.   COMM      0.   INDU      0.   OPEN    109.   AGRI      0.       109.
SAN LEANDRO-B-X

SAN LEANDRO            RESI   8697.   RESI      0.   COMM   2710.   INDU   2416.   OPEN   7745.   AGRI      0.     21568.
SANLEANDRO-C-X

--------------------   ------------   ------------   ------------   ------------   ------------   ------------   --------
    TOTAL AREA                23981.             0.          7944.          8980.         25452.             0.     66357.
```

NOTE : The model output presented in this figure is incomplete. It shows only one year out of three and only one of six subareas.

EXAMPLE OF DATACHK PROGRAM OUTPUT

Figure A-18 (concl.)

REPRESENTATIVE COSTS AND COMPUTER REQUIREMENTS

As stated in previous sections, the process of bringing the ABMAC program and preprocessor up will be system specific. This discussion will present information obtained from running the programs on an IBM 3033 and a Sperry Univac V76 minicomputer. The memory requirements and run cost relationships discussed for these two systems should aid the user in estimating how ABMAC and DATACHKM will respond on a different system.

The memory requirements of the compiled programs are presented in Table A-5. As ABMAC operates on a single subarea at a time its size is independent of the number of subareas. DATACHK is subarea dependent becaue of array requirements. The figures in Table A-5 for DATACHK are based on 25 subareas. When optimizing DATACHKM for a system and the supplied version does not fully utilize task memory, the extra memory should be examined as to the amount of array space it can accommodate. Each subarea requires as a minimum memory allocation, space for the three subroutine arrays listed at the beginning of the program. If it is determined that space exists for array requirements of 10 subareas the third dimension in the 3 arrays should be raised to 10.

TABLE A-5. MEMORY REQUIREMENTS
(total bytes)

	ABMAC	DATACHKM[1]
Sperry Univac Mini[2]	23K	16K
IBM 3033[3] Fortran compiler	20K	17K

(1) Based on 25 subarea array requirements
(2) Words are 2 bytes.
(3) Words are 4 bytes.

Typical costs of executing ABMAC and DATACHK programs are listed in Table A-6. These costs are based on runs for 6 subareas, two years of rainfall record, minimum printed output and no lateral inflows or outflows. A discussion of the effect of modifications on costs for the two programs follows:

1. different input configurations,
2. different printing options,
3. lateral flows,
4. larger rainfiles, and
5. more subareas.

ABMAC shows little cost sensitivity to the different input configurations. The IBM system showed a slight cost advantage for existing rainfile setups, whereas the Sperry Univac Mini indicated the consolidated setups were less expensive.

TABLE A-6. TYPICAL COSTS AND EXECUTION TIMES

	Execution Time	Total[3] Run Time	Total[4] Run Cost
IBM 3033 [1,2]			
ABMAC	2.99 sec	3.38 sec	$2.06
DATACHK	0.23 sec	0.54 sec	$0.44

		Total Run Time	Total[5] Run Cost
Sperry Univac Mini [2]			
ABMAC	Compilation	5 min, 32 sec	6.64 units
	Production run	1 min, 18 sec	1.56 units
DATACHK	Compilation	5 min, 36 sec	6.72 units
	Production run	0 min, 42 sec	0.84 units

(1) Costs do not include printing charges.
(2) Based on 6-subarea run, 2 years of rain record, average cost for all data input configurations.
(3) Includes compilation time of 0.33 sec. Note the IBM 3033 executes roughly 1.8 times faster than the IBM 370/168.
(4) CPU basic charge of $33/min batch mode ($0.55/sec).
(5) Basic charge of 0.02 units/sec. Cost per unit determined monthly depending on overhead and system operations costs.

The daily printing option can increase costs five fold over the subarea option on both systems. Runs exercising all three lateral flow files were 1.5 and 2.5 times more costly than a base run. Larger rain files will increase costs for ABMAC. A run using 10 years of record might be 5 times the execution time, and hence cost. The last factor influencing the program is increased number of subareas. ABMAC will have longer execution times and increased printout with increased number of subareas. The cost/subarea relationship appears to be linear (using approximately 0.3 cpu per subarea on the IBM 3033).

DATACHK does not have as many factors which influence run cost. Input configurations, printing option, and lateral flows have no effect on cost. Cost is independent of rainfile size for two input configurations with existing rain files, and is influenced much less than ABMAC by the other 3 configurations. An increased number of subareas and corresponding execution time is about the only other factor which influences cost of DATACHKM, so comparatively minor cost increases will be observed.

In summary, ABMAC has the potential for greatly increased run costs. DATACHK runs, once optimized for a computer system, should experience only small variability in costs.

REFERENCES

1. Field, R., 1975 "Coping with Urban Runoff in United States," Waste Research. Vol 9, pp. 499-505.

2. Heaney, Huber, and Nix, 1976, "Storm Water Management Model, Level I, Preliminary Screening Procedures," U.S. Environmental Protection Agency, EPA-600/2-76-275.

3. Kaiser Engineers, 1969, Final Report to the State of California San Francisco Bay Delta Water Quality Control Program, Chapter VII, California Water Quality Control Board, Sacramento, California.

4. Lager, J. A., and Smith, W. G., 1974, Urban Stormwater Management and Technology: An Assessment - USEPA National Environmental Research Center, Cincinnati, Ohio, EPA-670/2-74-040.

5. Metcalf & Eddy, Inc. & Resource Management Associates, 1976, "Report to ABAG, San Francisco Bay Region Surface Runoff Modeling."

6. Municipal Environmental Research Laboratory (MERL), 1976, "Areawide Assessment Procedures Manual," EPA 600/9-76-014.

APPENDIX A. LIST OF PROGRAM VARIABLES FOR ABMAC AND DATACHK PROGRAMS

ABMAC MAIN PROGRAM

VARIABLE NAME	INDEX[a]	DESCRIPTION	UNITS
AKOVER		Gross runoff coefficient override	--
AREA		Land use area (industrial, open, etc.)	acres
AUSE		Land use name (description)	--
CLIENT		Agency name	--
COEFX	C	Runoff Coefficient	MGal/in.
COEFY		Governing K factor	--
DAILY		Subroutine (called for each subarea)	--
ERFLAG	C	FATAL ERROR termination flag (1 = STOP)	--
FREQ	C	Printing option title chosen for run	--
FREQS		Data statement containing printing option titles	--
GAKOVR		Reference Gross Runoff Coefficient Override	--
GAREA		Reference Land Use Area	acres
GAUSE		Reference Land Use Name	--
GIQUAL		Reference Quality Option No.	--
GN1FLG		Reference Flag for Lateral Inflow	--
GN5FLG		Reference Flag for Input Rain Data	--
GN6FLG		Reference Flag for Treated Output Data	--
GN7FLG		Reference Flag for Overflow Output Data	--
GQC		Reference Land Use Quality Concentrations	mg/l

---

[a] C indicates variables in Common Block

VARIABLE NAME	INDEX	DESCRIPTION	UNITS
GRFAC		Reference Rain Factor	---
GSTMAX		Reference Maximum Storage Capacity Available	MGal
STRATE		Reference Max. Treatment Capacity Available	MGal/day
GWNAME		Reference Subarea Name	---
I		DO loop counter, Array dimension	---
I2		I + 2 or I + 4 depending on printing option	---
IDDATA		Array for Rain data calendar day	day
IMDATA		Array for Rain data calendar month	month
IOQUAL	C	IQUAL + 1	---
IPRINT	C	Printing Option Number	---
IQUAL		Quality Option Number	---
IRAIN		Array for Rain data	1/100 in.
J		DO loop counter, Array dimension	---
K		DO loop counter	---
L		Array dimension	---
M		Array dimension	---
MSTART		Water Year starting month	month
N1	C	Unit number of Lateral inflow	---
N1FLG		Flag for lateral inflow option	---
N5	C	Unit number of input rain data	---
N5FLG		Flag for existing rainfall option	---
N6	C	Unit number of treated output data	---
N6FLG		Flag for discharge output option	---

VARIABLE NAME	INDEX	DESCRIPTION	UNITS
N7	C	Unit number of overflow output data	---
N7FLG		Flag for spill output option	---
NCARD		Number of Rain data cards per year	---
NIN		Unit number of created rainfall file option chosen	---
NINFLG		Flag for created rainfall option	---
NINP		Unit number of input rain data, e.g. (0,5,NIN)	---
NSBCRD		Subarea card number	---
NSUB	C	Subarea DO loop counter	---
NSUBS	C	Number of subareas	---
QC		Land use Quality Concentrations	mg/l
QCRO	C	Effective Overall Runoff Concentrations	Klb/MGal
QCTR	C	Treated Concentration	Klb/MGal
QOPT	C	Quality Output Option	---
READNO	C	Unit number of card reader	---
RFAC	C	Rain factor multiplied by input rain	---
SARE		Total Subarea area	acres
SNROVF	C	Average number of days of runoff for all subareas	days
SNRRAI	C	Average number of days of rain for all subareas	days
SNRTRT	C	Average number of days of treatment for all subareas	days
SROVFL	C	Cumulative annual average volume overflowed for all subareas	MGal
SRPOLL	C	Cumulative annual average pollutant load for all subareas	Klb

VARIABLE NAME	INDEX	DESCRIPTION	UNITS
SRRAIN	C	Cumulative annual average volume rain for all subareas	MGal
SRRUNO	C	Cumulative annual average volume runoff for all subareas	MGal
SRSTOR	C	Maximum storage volume required in any subarea	MGal
SRTRTD	C	Cumulative annual average volume treated for all subareas	MGal
STMAX	C	Maximum storage capacity available	MGal
TEMPCD		Temporary buffer containing current input data	---
TRRATE	C	Maximum treatment capacity available	MGal/day
WASHED	C	Watershed name	---
WNAME	C	Subarea name	---
WRITNO	C	Unit number of printer	---
YDATA		Calendar year	year
YSTART	C	Water Year starting year	year

ABMAC DAILY SUBROUTINE

VARIABLE NAME	INDEX	DESCRIPTION	UNITS
ANROVF		Average number of days of runoff for a subarea	days
ANRRAI		Avg no. of days of rain for a subarea	days
ANRTRT		Avg no. of days of treatment for a subarea	days
ARAIN		Array of rain input data (10 points)	inches
AROVFL		Avg annual volume overflowed for a subarea	MGal
ARPOLL		Avg annual pollutant load for a subarea	Klb
ARRAIN		Avg annual rain volume for a subarea	MGal
ARRUNO		Avg annual runoff for a subarea	MGal
ARSTOR		Maximum storage capacity required	MGal
ARTRTD		Avg annual treated volume	MGal
COEFX	C	Runoff coefficient	MGal/in.
DAILY		Subroutine name	---
DDATA		Calendar day of current rain data	---
DDATAP		Calendar day of previous rain data	---
DDATLQ		Calendar day of current lateral inflow data	---
DLATQ		Lateral inflow for current day	MGal
DLQ		Flow for current lateral inflow data	MGal
DOVFL		Overflow occurring on current day	MGal
DPOLL		Pollutant loads on current day	Klb
DPOLLQ		Pollutant loads in lateral inflow current day	Klb
DPRES		Current calendar day in day loop	---
DRAIN		Calculated rainfall for current day	inches
DRUNOF		Runoff for current day	MGal

VARIABLE NAME	INDEX	DESCRIPTION	UNITS
DSTOR		Storage required during current day	MGal
DTRTD		Treated flow for current day	MGal
ERFLAG	C	FATAL ERROR TERMINATION FLAG	---
FREQ	C	Printing option title chosen for run	---
I		DO loop counter, array dimension	---
IDDATA		Array for rain data calendar day	day
IEND		Internal flag for end of input data	---
IGAP		Flag for continuity break in input data	---
IHEADG		Flag for suppression of zero daily data	---
IMDATA		Array for rain data calendar month	---
INFLAG		Flag for match of current date and lateral inflow date	---
IOQUAL	C	IQUAL + 1	---
IPRINT	C	Printing option	---
IYCNT		Print control for number of years per page	---
K		DO loop counter, array dimension	---
L		DO loop counter, array dimension	---
MDATA		Calendar month of current rain data	---
MDATAP		Calendar month of previous rain data	---
MDATLQ		Calendar month of lateral inflow data	---
MOVFL		Total overflow occurring during current month	MGal
MPOLL		Total pollutant load during current month	Klb
MPRES		Current calendar month	---

VARIABLE NAME	INDEX	DESCRIPTION	UNITS
MPREV		Previous calendar month	---
MRAIN		Total calculated rainfall for current month	inches
MRUNOF		Total runoff for current month	MGal
MSTART		Water year starting month	month
MSTOR		Maximum daily storage during month	MGal
MTRTD		Total treated flow during current month	MGal
N1		Unit number for lateral inflow file	---
N5		Unit number for rain data file	---
N6		Unit number for treated output file	---
N7		Unit number for overflow output file	---
NCARD		Number of rain data cards for year	---
NCRD		Card consolidation option	---
NDAT		Counter for reading data from ARAIN	---
NDOVFL		Counter if overflow occurred on current day	---
NDPM		Number of days per month DATA	---
NDRAIN		Flag for rain during current day	---
NDTRTD		Flag for treatment during current day	---
NGAP		Number of current rain data inputs in ARAIN	---
NMOVFL		Total number of days of overflow in month	days
NMRAIN		Total number of days of rain in month	days
NMTRTD		Total number of days treated in month	days
NROVFL		Total number of days overflow for subarea	days
NRRAIN		Total number of days of rain for subarea	days

VARIABLE NAME	INDEX	DESCRIPTION	UNITS
NRTRTD		Total number of days treated for subarea	days
NSUB	C	Subarea DO loop counter	---
NSUBS	C	Number of subareas	---
NYEAR		Counter for number of water years processed	---
NYOVFL		Total number of days overflow in year	days
NYRAIN		Total number of days rain in year	days
NYTRTD		Total number of days treated in year	days
QCRO	C	Effective overall runoff concentrations	Klb/MGal
QCTR	C	Treated concentration	Klb/MGal
QOPT	C	Quality output option	---
RAIN		Rainfall for current day from ARAIN	inches
READNO		Unit number of card reader	---
RFAC	C	Rain factor	---
ROVFL		Total overflow for subarea	MGal
RPOLL		Total pollutant loads for subarea	Klb
RRAIN		Total rain for subarea	inches
RRUNOF		Total runoff for subarea	MGal
RSTOR		Maximum storage for subarea	MGal
RTRTD		Total treated for subarea	MGal
SNROVF	C	Average number of days of runoff for all subareas	days
SNRRAI	C	Avg no. of days of rain for all subareas	days

VARIABLE NAME	INDEX	DESCRIPTION	UNITS
SNRTRT	C	Average number of days treatment for all subareas	days
SROVFL	C	Cumulative annual average volume overflow for all subareas	MGal
SRPOLL	C	Cum. ann. avg pollutant load for all subareas	Klb
SRRAIN	C	Cum. ann. avg rainfall for all subareas	MGal
SRRUNO	C	Cum. ann. avg runoff for all subareas	MGal
SRSTOR	C	Max. storage vol. req'd in any subarea	MGal
SRTRTD	C	Cum. ann. avg treated for all subareas	MGal
STMAX	C	Maximum storage capacity available	MGal
STORA		Total volume to be distributed in current day	MGal
STOROV		Overflow occurring on current day	MGal
TRRATE	C	Maximum treatment capacity available	MGal
WASHED	C	Watershed name	---
WMONTH		Data array of month titles	---
WNAME	C	Subarea name	---
WRITNO		Unit number of printer	---
YBEGIN		Calendar year of first rain data	year
YDATA		Calendar year	year
YDATAP		Calendar year of previous rain data	year
YDATLQ		Calendar year of lateral inflow data	year
YOVFL		Total overflow volume in year	MGal
YPOLL		Total pollutant load in year	Klb

VARIABLE NAME	INDEX	DESCRIPTION	UNITS
YPRES		Current calendar year	year
YPREV		Previous calendar year	year
YRAIN		Total rainfall in year	inches
YRUNOF		Total volume runoff in year	MGal
YSTOR		Maximum storage capacity required in year	MGal
YTRTD		Total volume treated in year	MGal
YSTART		Calendar year starting year	year

DATACHK MAIN PROGRAM

VARIABLE NAME	INDEX	DESCRIPTION	UNITS
ALAND	C	Array for Land Use subroutine	---
APARAM	C	Array for Miscellaneous Parameter subroutine	---
AQUAL	C	Array for Quality Subroutine	
CLIENT		Agency name	---
GAKOVR		Reference Gross Runoff Coefficient override	---
GAREA		Reference Land Use Area	acres
GAUSE		Reference Land Use Name	---
GIQUAL		Reference Quality Option Number	---
GN1FLG		Ref. flag for Lateral Inflow option	---
GN5FLG		Ref. flag for Input Rain Data option	---
GN6FLG		Ref. flag for treated Output Data option	---
GN7FLG		Ref. flag for Overflow Output Data option	---
GQC		Ref. Land Use Quality Concentrations	mg/l.
GRFAC		Ref. Rain Factor	---
GSTMAX		Ref. maximum storage capacity available	MGal
GTRATE		Ref. maximum treatment capacity available	MGal/day
GWNAME		Ref. subarea name	---
IDDATA		Array for rain data calendar day	day
IMDATA		Array for rain data calendar month	month
IPRINT		Printing option number	---

VARIABLE NAME	INDEX	DESCRIPTION	UNITS
IRAIN		Array for rain data	1/100 in.
NCARD		Number of rain data cards per year	---
NCRD		Card consolidation option	---
NIN		Unit number of created rain file	---
NINFLG		Flag for created rain file option	---
NSBCRD		Subarea card number	---
NSUB		Subarea DO loop counter	---
NSUBS	C	Number of subareas	---
N5FLG		Flag for input rain file option	---
I		DO loop counter, array dimension	---
J		DO loop counter, array dimension	---
K		DO loop counter, array dimension	---
L		Array dimension	---
READNO	C	Unit number of Card Reader	---
SLAND		Land subroutine name	---
SPARAM		Miscellaneous Parameter subroutine name	---
SQUAL		Quality subroutine name	---
TEMPCD		Temporary buffer--contains current input data	---
WRITNO	C	Unit number of printer	---
YDATA		Calendar year	year

DATACHK SPARAM SUBROUTINE

VARIABLE NAME	INDEX	DESCRIPTION	UNITS
APARAM	C	Array for Miscellaneous Parameters subroutine	---
F		Variable dimension for assigning error flag	---
FLAG		Variable for specific error flag	---
FLAGS		Data statement containing error symbols	---
FREQ		Printing option title chosen for run	---
FREQS		Data statement containing printing option titles	---
I		DO loop counter, array dimension	---
I2		I + 2 or I + 4 depending on printing option	---
ICNT		Heading counter	---
IHEADG		Heading control	---
IOQUAL		APARAM (3,5,K) + 1	---
IPRINT		Printing option number	---
J		DO loop counter, array dimension	---
K		DO loop counter, array dimension	---
L		Array dimension	---
M		Array dimension	---
MSTART		Water year	---
NCRD		Card consolidation option	---
NSUBS		Number of subareas	---
QOPTS		Data statement containing quality option descriptions	---
READNO		Unit number for Card Reader	---
SPARAM		Subroutine name	---
WRITNO		Unit number for printer	---
YSTART		Water year starting year	---

DATACHK SLAND SUBROUTINE

VARIABLE NAME	INDEX	DESCRIPTION	UNITS
ALAND		Array for land subroutine	---
I		DO loop counter, array dimension	---
ICNT		Heading counter	---
IHEADG		Heading control	---
J		DO loop counter, array dimension	---
K		DO loop counter, array dimension	---
L		DO loop counter, array dimension	---
NSUBS		Number of subareas	---
READNO		Unit number of Card Reader	---
SARE		Subarea total acreage, each subarea, all land uses	acres
SLAND		Subroutine name	---
TAREA		Total acreage, all subareas, each land use	acres
TSARE		Total subarea acreages, all subareas, all land uses	acres
WRITNO		Unit number for printer	---

DATACHK SQUAL SUBROUTINE

VARIABLE NAME	INDEX	DESCRIPTION	UNITS
AQUAL		Array for Quality subroutine	---
CTITLE		Data statement containing full pollutant names	---
I		DO loop counter, array dimension	---
ICNT		Heading counter	---
I2		I1 + 6	---
I1		J + (6*N) - 1	---
IHEADG		Heading control	---
J		DO loop counter, array dimension	---
K		DO loop counter, array dimension	---
L		Array dimension	---
N		J - 2	---
NSUBS		Number of subareas	---
PTITLE		Data statement containing abbreviated pollutant names	---
SQUAL		Subroutine name	---
QCAVG		Average quality concentration	mg/l.
QCMAX		Maximum quality concentration	mg/l.
QCMIN		Minimum quality concentration	mg/l.
READNO		Unit number of Card Reader	---
SUBCNT		Counter of subareas with nonzero quality concentrations	---
WRITNO		Unit number of printer	---

APPENDIX B. ABMAC AND DATACHK SOURCE LISTING

```
C-----------------------------------------------------------------------
C      ************************************************
C        MAC MODEL       VERSION 3M      11/25/80
C        ABMAC3
C             ABAG  MINI  APPLICATION (J6098)
C
C      ************************************************
C      USER:      H. G. SMITH
C      OWNER:     METCALF & EDDY, INC., ENGINEERS
C                 1029 CORPORATION WAY
C                 PALO ALTO, CALIF. 94303
C                     TEL:  415/964-7100
C      ************************************************
      DIMENSION  AUSE(7,5),QC(7,7),AREA(6),GQC(7,7),GAUSE(7,5),GAREA(6),
     *           GWNAME(5),
     *           FREQS(8),CLIENT(5),IMDATA(10),IDDATA(10),IRAIN(10)
      INTEGER*4 YDATA,SNRRAI,SNROVF,READNO,WRITNO,MSTART,YSTART,ERFLAG,
     *          GN1FLG,GN5FLG,GN6FLG,GN7FLG,GIQUAL
      REAL*4 AUSE,QC,AREA,GQC,GAREA,GAUSE,GWNAME
      REAL*8 SRRAIN,SRRUNO,SROVFL,SRTRTD,SRSTOR,SRPOLL,SNRTRT
      COMMON SRRAIN,SRRUNO,SROVFL,SRTRTD,SRSTOR,SRPOLL(6),SNRTRT,
     *       STMAX,TRRATE,COEFX,RFAC,QCRO(7),WNAME(5),WASHED(5),
     *       QCTR(7),FREQ(2),SNRRAI,SNROVF,NSUB,NSUBS,IOQUAL,
     *       IPRINT,N1,N5,N6,N7,READNO,WRITNO,MSTART,YSTART,ERFLAG
C
      COMMON  /QOPTS/  QOPT(5,4)
      DATA FREQS/'  DA','ILY ','MONT','HLY ','YEAR','LY  ','SUBA',
     *           'REA '/
C
C?????OPEN DATA INPUT FILE HERE IF REQUIRED.
C
C     LOGICAL UNIT DEFAULTS ARE SET FOR INPUT DATASTREAM(CARD READER)-
C     READNO, LINE PRINTER-WRITNO,RAINFILE-NIN OR N5,LATERAL INFLOW-N1
C     OUTPUT FILES-N6 AND/OR N7.  CHANGE FOLLOWING LINES IF SYSTEM
C     DEFAULTS NEED TO BE DIFFERENT.
C
      READNO = 9
      WRITNO = 6
      NIN    = 1
      N1     = 13
      N5     = 11
      N6     = 12
      N7     = 13
C
      WRITE(WRITNO,10)
   10 FORMAT(1H1,5X,'ABAGMAC (VERSION 3M, NOV 25,1980)  SIMULATION',
     *' STARTED',////)
C
C          READ NO. OF SUBAREAS,  PRINTING OPTION, USER HEADING,
C          INPUT FILE NO., CARD CONSOLIDATION OPTION.
C
      READ(READNO,15)NSUBS,IPRINT,(CLIENT(I),I=1,5),NINFLG,NCRD,
     *      MSTART,YSTART
   15 FORMAT(I2,I4,4X,5A4,8X,I2,8X,I2,8X,I2,I4)
C     SET DEFAULT PRINT OPTION IF NECESSARY
      IF (IPRINT .EQ. 0) IPRINT=4
C
C    ESTABLISH TITLES BASED ON CHOSEN PRINTING OPTION
C            TITLES
      DO 20  I=1,2
```

```
         I2=I                                                          MAIN 61
        IF (IPRINT .EQ. 2)  I2 = I + 2                                 MAIN 62
        IF (IPRINT .EQ. 3)  I2 = I + 4                                 MAIN 63
        IF (IPRINT .EQ. 4)  I2 = I + 6                                 MAIN 64
   20     FREQ(I)=FREQS(I2)                                            MAIN 65
C                                                                      MAIN 66
        IF (NINFLG .NE. 0) GO TO 25                                    MAIN 67
        NIN  = 0                                                       MAIN 68
C                                                                      MAIN 69
C        IF SUBAREA CARD CONSOLIDATION OPTION                          MAIN 70
C        IS CHOSEN READ AND STORE REFERENCE VARIABLES                  MAIN 71
C                                                                      MAIN 72
 25     IF (NCRD .NE. 1) GO TO 55                                      MAIN 73
        DO 41 L=2,8                                                    MAIN 74
           I=L - 1                                                     MAIN 75
           READ(READNO,43) NSBCRD,(GAUSE(I,K),K=1,5),(GQC(I,K),K=1,7)  MAIN 76
           IF (NSBCRD .NE. L) GO TO 47                                 MAIN 77
 43        FORMAT(I2,5A4,2X,7F8.2)                                     MAIN 78
 41     CONTINUE                                                       MAIN 79
        READ(READNO,43) NSBCRD,(GWNAME(I),I=1,5),(GAREA(I),I=1,6)      MAIN 80
        IF (NSBCRD .NE. 9) GO TO 47                                    MAIN 81
        READ(READNO,430)NSBCRD,GN1FLG,GN5FLG,GN6FLG,GN7FLG,GAKOVR,GSTMAX, MAIN 82
     *      GTRATE,GRFAC,GIQUAL                                        MAIN 83
 430    FORMAT(I2,I2,6X,3I2,8X,4F8.2,I1)                               MAIN 84
        IF (NSBCRD .NE. 10) GO TO 47                                   MAIN 85
        GO TO 55                                                       MAIN 86
   47 WRITE(WRITNO,45)                                                 MAIN 87
   45 FORMAT (1X,'IMPROPER NUMBER OF SUBAREA CARDS',                   MAIN 88
     *    ' OR CARD DECK DOES NOT START WITH 02')                      MAIN 89
      GO TO 90909                                                      MAIN 90
C                                                                      MAIN 91
C           WRITE NO. OF SUBAREAS, MONTHLY AND/OR DAILY PRINTING OPTION, MAIN 92
C           INPUT FILE NO., CARD CONSOLIDATION OPTION.                 MAIN 93
C                                                                      MAIN 94
   55 WRITE(WRITNO,60) NSUBS,FREQ,NINFLG,NCRD                          MAIN 95
   60 FORMAT(1H0,//////,T28,'INITIAL INPUT DATA',/,T10,55('-'),////,   MAIN 96
     *T10,'NO. OF SUBAREAS',T40,'=',T43,I2,////,T10,                   MAIN 97
     *'PRINTING OPTION IN EFFECT',T40,'=',T43,2A4,                     MAIN 98
     *////,T10,'RAINFALL INPUT OPTION ',T40,'=',T43,I2,                MAIN 99
     *5X,'(WHEN NOT OVERRIDDEN BY A NONZERO VALUE OF N5)',             MAIN 100
     *   ////,T10,'CARD CONSOLIDATION OPTION ',T40,'=',T43,I2)         MAIN 101
      IF (NIN) 142,144,146                                             MAIN 102
  142 WRITE(WRITNO,61) NIN                                             MAIN 103
   61 FORMAT(1H1,'COMPUTATION STOPPED. INPUT FILE IS NEGATIVE',I4,'.') MAIN 104
      GO TO 90909                                                      MAIN 105
  144   NINP = READNO                                                  MAIN 106
      GO TO 1110                                                       MAIN 107
  146   NINP = NIN                                                     MAIN 108
        IF (NINP .EQ. READNO) GO TO 1110                               MAIN 109
C                                                                      MAIN 110
C     IF NINP NOT EQUAL TO READNO OR 0 AND NCRD IS EQUAL TO 1 READ INPUT MAIN 111
C     TO ESTABLISH DISC/TAPE FILE FOR REFERENCE.                       MAIN 112
C                                                                      MAIN 113
C?????OPEN RAIN FILE FOR WRITING IF REQUIRED                           MAIN 114
C                                                                      MAIN 115
  147 READ(READNO,148) YDATA,NCARD                                     MAIN 116
  148 FORMAT(6X,I4,6X,I4)                                              MAIN 117
      IF (YSTART .EQ.0) GO TO 1148                                     MAIN 117
      IF (YDATA.LT.YSTART) GO TO 1146                                  MAIN 117
      GO TO 1148                                                       MAIN 117
 1146 WRITE (6,1147) YDATA,YSTART
 1147 FORMAT (1X,'COMPUTATION STOPPED.  CALENDAR YEAR OF DATA(',I4,
     *       ') IS BEFORE SPECIFIED STARTING YEAR(',I4,')')
      GO TO 90909
 1148 CONTINUE
C
      IF ( YDATA .EQ. 9999) GO TO 149
      WRITE(NINP,148) YDATA,NCARD
      DO 150 I=1,NCARD
      READ(READNO,151) (IMDATA(L),IDDATA(L),IRAIN(L),L=1,10)
  151 FORMAT(10(2I2,I4))
  150 WRITE(NINP,151) (IMDATA(L),IDDATA(L),IRAIN(L),L=1,10)
      GO TO 147
  149 CONTINUE
      WRITE(NINP,153)
  153 FORMAT('99999999999999999999')
      REWIND NINP
C?????CLOSE RAIN FILE IF REQUIRED
C     REWIND USED TO CLOSE RAIN FILE
C
C                            PRELIMINARY INITIALIZATION
C
 1110 SRRAIN = 0.0
      SNRRAI = 0
      SRRUNO = 0.0
      SROVFL = 0.0
      SRTRTD = 0.0
      SNROVF = 0
      SNRTRT = 0
      SRSTOR = 0.0
      ERFLAG = 0
      DO 1108 K=1,6
 1108 SRPOLL(K) = 0.0
C     READ TEMPCARD
C
      IF (NCRD .NE. 1) GO TO 1111
      READ(READNO,44) NSBCRD
 44   FORMAT(I2)
      IF (NSBCRD .EQ. 1) GO TO 1111
      WRITE (WRITNO,11111)
11111 FORMAT(1X,'SUBAREA CARD DECK DOES NOT START WITH 01')
      GO TO 90909
C
C          REPEAT ENTIRE PROGRAM BELOW FOR EACH OF THE 'NSUBS' SUBAREAS
C
 1111 DO 99999 NSUB=1,NSUBS
C
C      PRINT INITIAL HEADING
C
      WRITE(WRITNO,62)(CLIENT(I),I=1,5)
   62 FORMAT(1H1,T46,5A4,T91,16HMETCALF & EDDY, ,
     *15HINC., ENGINEERS,/,T46,20('-'),T91,20H1029 CORPORATION WAY,
     */,T46,20('-'),T91,15HP.O. BOX 10-046,/,
     *T91,23HPALO ALTO, CALIF. 94303////)
C
C     IF CARD CONSOLIDATION (CARD CONSOL.) OPTION IS IN EFFECT READ
C     SUBAREA INPUT DATA FROM INPUT CARDS AND REFERENCE VARIABLES AS
C     REQUIRED.
C
      IF (NCRD .NE. 1) GO TO 120
```

```
C
C     NOTE THE PROGRAM WILL BLOW UP IF RAIN DATA OCCURS BETWEEN
C     SUBAREA CARDS WHEN NCRD=1.
C
      BACKSPACE READNO
      READ (READNO,6200) WASHED
 6200 FORMAT(2X,5A4)
      READ(READNO,44) NSBCRD
      IF (NSBCRD .NE. 99) GO TO 101
      I = 2
      GO TO 1112
C     BEGIN LOOP TO ASSIGN SUBAREA PARAMETERS IF CONSOLIDATION
C     OPTION IS IN EFFECT.
C
  101 DO 102 I=2,10
      IF (NSBCRD-I) 109,106,108
C
C  CARD CONSOL.   NEGATIVE VALUE - DETERMINE WHETHER CARDS ARE OUT OF
C         ORDER OR WHETHER NEXT '01' CARD WAS READ
C
  109 IF (NSBCRD .EQ. 1) GO TO 112
      WRITE(WRITNO,113)
  113 FORMAT(1X,'INPUT CARDS OUT OF ORDER')
      GO TO 90909
C
C   ASSIGN REST OF CARDS FROM REFERENCE VARIABLES
C
  112 DO 118 J=I,10
      L = J - 1
      IF (J .LE. 8) GO TO 4000
      IF (J .EQ. 9) GO TO 4300
      IF (J .EQ.10) GO TO 4500
 4000 DO 4010 K=1,5
 4010    AUSE(L,K) = GAUSE(L,K)
      DO 4020 K=1,7
 4020    QC(L,K) = GQC(L,K)
      GO TO 118
C
 4300 DO 4310 K=1,5
 4310    WNAME(K) = GWNAME(K)
      DO 4320 K=1,6
 4320    AREA(K) = GAREA(K)
      GO TO 118
C
 4500 N1FLG = GN1FLG
      N5FLG = GN5FLG
      N6FLG = GN6FLG
      N7FLG = GN7FLG
      AKOVER = GAKOVR
      STMAX  = GSTMAX
      TRRATE = GTRATE
      RFAC   = GRFAC
      IQUAL  = GIQUAL
  118 CONTINUE
      GO TO 130
C
C  CARD CONSOL.  ZERO VALUE ASSIGN PARAMETERS FROM INPUT DATA
C
  106 M = NSBCRD - 1
      BACKSPACE READNO
      IF (NSBCRD .LE. 8) GO TO 122
      IF (NSBCRD .EQ. 9) GO TO 124
      IF (NSBCRD .EQ.10) GO TO 126
  122 READ(READNO,52) (AUSE(M,K),K=1,5),(QC(M,K),K=1,7)
      GO TO 127
  124 READ(READNO,52) (WNAME(K),K=1,5),(AREA(K),K=1,6)
      GO TO 127
  126 READ(READNO,53) N1FLG,N5FLG,N6FLG,N7FLG,AKOVER,STMAX,TRRATE,
     *  RFAC,IQUAL
  127 READ(READNO,44) NSBCRD
      GO TO 102
C
C  CARD CONSOL.  POSITIVE VALUE ASSIGN VALUES FROM REFERENCE VARIABLES
C
  108 L = I - 1
      IF (I .LE. 8) GO TO 5000
      IF (I .EQ. 9) GO TO 5300
      IF (I .EQ.10) GO TO 5500
 5000 DO 5010 K=1,5
 5010    AUSE(L,K) = GAUSE(L,K)
      DO 5020 K=1,7
 5020    QC(L,K) = GQC(L,K)
      GO TO 102
C
 5300 DO 5310 K=1,5
 5310    WNAME(K) = GWNAME(K)
      DO 5320 K=1,6
 5320    AREA(K) = GAREA(K)
      GO TO 102
C
 5500 N1FLG = GN1FLG
      N5FLG = GN5FLG
      N6FLG = GN6FLG
      N7FLG = GN7FLG
      AKOVER = GAKOVR
      STMAX  = GSTMAX
      TRRATE = GTRATE
      RFAC   = GRFAC
      IQUAL  = GIQUAL
C
  102 CONTINUE
C
      GO TO 1119
C
C   ASSIGN REST OF CARDS LAST SUBAREA (CARD CONSOL. NEGATIVE VALUE)
C
 1112 DO 1118 J=I,10
      L = J - 1
      IF (J .LE. 8) GO TO 6000
      IF (J .EQ. 9) GO TO 6300
      IF (J .EQ.10) GO TO 6500
 6000 DO 6010 K=1,5
 6010    AUSE(L,K) = GAUSE(L,K)
      DO 6020 K=1,7
 6020    QC(L,K) = GQC(L,K)
      GO TO 1118
C
 6300 DO 6310 K=1,5
 6310    WNAME(K) = GWNAME(K)
      DO 6320 K=1,6
 6320    AREA(K) = GAREA(K)
      GO TO 1118
C
 6500 N1FLG = GN1FLG
      N5FLG = GN5FLG
      N6FLG = GN6FLG
      N7FLG = GN7FLG
      AKOVER = GAKOVR
      STMAX  = GSTMAX
      TRRATE = GTRATE
      RFAC   = GRFAC
      IQUAL  = GIQUAL
 1118 CONTINUE
C
C  BYPASS CONVENTIONAL READ AND ASSIGNMENT STATEMENTS.(NCRD=1)
C
 1119 GO TO 130
C
C          READ WATERSHED NAME
C
  120 READ(READNO,51)WASHED
51    FORMAT(2X,5A4)
C
C          READ LAND USE; RUNOFF COEFFICIENT; BOD, SS, VSS, TOTAL N,
C          TOTAL P, OTHER CONCENTRATIONS IN MG/L, FOR EACH OF 6 LAND USE
C
      DO 200  I=1,7
  200 READ(READNO,52)  (AUSE(I,K),K=1,5),(QC(I,K),K=1,7)
   52 FORMAT(2X,5A4,2X,7F8.2)
C
C          READ WATERSHED (ALT.) NAME, 6 LAND USE AREAS (IN ACRES)
C
      READ(READNO,52)  (WNAME(I),I=1,5),(AREA(I),I=1,6)
C
C          READ:   I/O CONTROLS, GROSS RUNOFF COEFFICIENT (OVERRIDE),
C          MAX STORAGE VOLUME IN MG., TREATMENT WITHDRAWL RATE IN MGD.
C          RAINFALL MULTIPLIER, AND QUALITY OPTION
C
      READ(READNO,53) N1FLG,N5FLG,N6FLG,N7FLG,AKOVER,STMAX,TRRATE,RFAC,
     *                IQUAL
   53 FORMAT(2X,I2,6X,3I2,8X,4F8.2,I1)
C
C     END OF INITIAL READ STATEMENTS
C
  130 IOQUAL = IQUAL + 1
C
C?????RESET LOGICAL UNIT DEFAULTS
C
C     LOGICAL UNIT DEFAULTS ARE SET FOR RAINFILE-N5, LATERAL INFLOW-N1
C     OUTPUT FILES-N6 AND/OR N7.  CHANGE FOLLOWING LINES IF SYSTEM
C     DEFAULTS NEED TO BE DIFFERENT.
C
      N1     = 13
      N5     = 11
      N6     = 12
      N7     = 13
C
C     TEST FILE FLAGS TO REASSIGN LOGICAL UNIT NUMBERS IF REQUIRED
C
      IF (N1FLG .NE. 0) GO TO 1302
      N1    = 0
 1302 IF (N5FLG .NE. 0) GO TO 1304
      N5    = 0
 1304 IF (N6FLG .NE. 0) GO TO 1306
      N6    = 0
 1306 IF (N7FLG .NE. 0) GO TO 1308
      N7    = 0
 1308 CONTINUE
C
      IF (N5 .NE. 0.AND.N5.NE.NINP)  GO TO 300
C          READ FROM GLOBAL UNIT
        N5 = NINP
C
C          WRITE WATERSHED NAME, SUBAREA NAME, HEADINGS
C
  300 WRITE(WRITNO,63)  WASHED,(WNAME(I),I=1,5)
   63 FORMAT(28X,5A4,10X,5A4/5X,94('-')/,
     *          49X,'POLLUTANT CONCENTRATION IN SURFACE RUNOFF, MG/L',/,
     129X,'AREA',14X,52('-'),/,11X,'LAND USE',10X,'ACRES   K-FACTOR',
     24X,'BOD',6X,'SS',7X,'VSS',5X,'TOT N',4X,'TOT P',4X,'OTHERS',/,
     35X,20('-'),3X,'--------',2X,8('-'),6('  -------'),/ )
C
C          WRITE LAND USE; AREA; RUNOFF FACTOR; BOD, SS, VSS, TOTAL N,
C          TOTAL P, OTHER CONCENTRATIONS IN MG/L FOR EACH LAND USE
C
      DO 350  I=1,6
  350 WRITE(WRITNO,65)  (AUSE(I,K),K=1,5),AREA(I),(QC(I,K),K=1,7)
   65 FORMAT(5X,5A4,2X,1F8.0,F8.2,2X,6F9.2)
C
C          WRITE TREATED WITHDRAWAL POLLUTANT CONCENTRATIONS
C
      WRITE(WRITNO,66)  (AUSE(7,K),K=1,5),(QC(7,K),K=2,7)
   66 FORMAT(/5X,40('-'),/,5X,35HQUALITY OF WITHDRAWAL FROM STORAGE:,
     *          /5X,5A4,20X,6F9.2)
C          COMPUTE EFFECTIVE OVERALL RUNOFF CONCENTRATIONS
      DO 435  K=1,7
  435   QCRO(K) = 0.0
        SARE = 0.0
      DO 440  I=1,6
  440   SARE = SARE + AREA(I)
      DO 450  I=1,6
  450   QCRO(1) = QCRO(1)+AREA(I)*QC(I,1)
        COEFX = QCRO(1)*.027156
      DO 470  K = 2,7
      DO 460  I=1,6
  460   QCRO(K) = QCRO(K) + AREA(I)*QC(I,1)*QC(I,K)
      IF (COEFX .LE. 0)  GO TO 470
        QCRO(K) = QCRO(K)*8.345/(COEFX*1000.)*.027156
  470 CONTINUE
C
C          TEST FOR RUNOFF COEFFICIENT OVERRIDE
C
      IF (AKOVER .GT. 0.0)  COEFX = AKOVER*SARE*0.027156
        COEFY = 0.0
      IF (SARE .EQ. 0.0)  GO TO 475
        COEFY = COEFX/(0.027156*SARE)
  475 DO 480  K = 2,7
  480   QCTR(K) = QC(7,K)*8.345/1000.
      WRITE(WRITNO,68)
   68 FORMAT(//,5X,10HTOTAL AREA,2X,8HK-FACTOR,8X,11HMAX STORAGE,
     *5X,15HWITHDRAWAL RATE,2X,8HRAINFALL,12X,7HQUALITY,                MAIN 412
     * /,8X,5HACRES,4X,                                                 MAIN 413
     *8HOVERRIDE,12X,4HMGAL,12X,6HMGAL/D,8X,                            MAIN 414
     *6HFACTOR,13X,6HOPTION,                                            MAIN 415
     */,5X,10(1H-),2X,8(1H-),6X,                                        MAIN 416
     *15('-'),3X,15('-'),2X,8('-'),4X,24('-'))                          MAIN 417
C                                                                       MAIN 418
C          WRITE TOTAL AREA, K-FACTOR OVERRIDE, MAX STORAGE VOLUME,     MAIN 419
C          WITHDRAWAL (TREATMENT) RATE, RAINFALL FACTOR,                MAIN 420
C          QUALITY OPTION, AND OUTPUT OPTION.                           MAIN 421
C                                                                       MAIN 422
      WRITE(WRITNO,69)SARE,AKOVER,STMAX,TRRATE,RFAC,IQUAL,              MAIN 423
     *     (QOPT(L,IOQUAL),L=1,5)                                       MAIN 424
   69 FORMAT(6X,F7.0,4X,F7.2,10X,F6.1,13X,F8.1,5X,F8.2,3X,I2,           MAIN 425
     *       2X,5A4,//)                                                 MAIN 426
      WRITE(WRITNO,70)  N5FLG                                           MAIN 427
   70 FORMAT(5X,'RAIN INPUT FILE :',13X,'FILE OPTION',4X,I2,//)         MAIN 428
C     N5 ASSIGNED IN SUBAREA CARD OVERRIDES N5 ASSIGNED IN GLOBAL CARD  MAIN 429
C                                                                       MAIN 430
      WRITE(WRITNO,603) N1FLG                                           MAIN 431
  603 FORMAT(5X,'LATERAL FLOW INPUT FILE :',5X,'FILE OPTION',4X,I2,//)  MAIN 432
C                                                                       MAIN 433
C     WRITE OUTPUT FILE INFORMATION                                     MAIN 434
C                                                                       MAIN 435
      WRITE(WRITNO,605) N6FLG,(QOPT(J,3),J=1,5),N7FLG,(QOPT(J,2),J=1,5) MAIN 436
  605 FORMAT(5X,'OUTPUT OUTFLOW FILES :',2(T36,'FILE OPTION',4X,I2,     MAIN 437
     *   4X,5A4,/),/)                                                   MAIN 438
      WRITE(WRITNO,820)                                                 MAIN 439
 820  FORMAT(1H ,4X,'* : REFERS TO MAXIMUM VALUES.',//)                 MAIN 440
  500 WRITE(WRITNO,73)  COEFY                                           MAIN 441
   73 FORMAT(1H ,4X,'GOVERNING K-FACTOR =',F5.2,//)                     MAIN 442
      WRITE(WRITNO,5100) MSTART,YSTART                                  MAIN 443
 5100 FORMAT(1H ,4X,'WATER YEAR STARTING MONTH IS ',I2,' ;  STARTING',  MAIN 444
     *       ' YEAR IS ',I5)                                            MAIN 445
C                                                                       MAIN 446
C                                                                       MAIN 447
  600   CALL DAILY                                                      MAIN 448
      IF (ERFLAG .EQ. 1) GO TO 90909                                    MAIN 449
C                                                                       MAIN 450
99999 CONTINUE                                                          MAIN 451
      WRITE(WRITNO,82)                                                  MAIN 452
   82 FORMAT(1H1,/////,5X,37HABAGMAC (VERSION 3M) SIMULATION ENDED,     MAIN 453
     */////)                                                            MAIN 454
C                                                                       MAIN 455
C?????CLOSE INPUT DATA FILE IF REQUIRED                                 MAIN 456
C                                                                       MAIN 457
      WRITE(WRITNO,821)                                                 MAIN 458
 821  FORMAT(1H1)                                                       MAIN 459
90909 RETURN                                                            MAIN 460
      END                                                               MAIN 461
C-----------------------------------------------------------------------MAIN 462
C--------------------------------------------------------               BLOCK1
      BLOCK DATA                                                        BLOCK2
      COMMON  /QOPTS/  QOPT(5,4)                                        BLOCK3
      DATA QOPT/'    ','   R','UNOF','F   ','    ',                       BLOCK4
     *          '    ','  OV','ERFL','OW  ','    ',                       BLOCK5
     *          '    ',' TRE','ATME','NT  ','    ',                       BLOCK6
     *          'OVER','FLOW',' + T','REAT','MENT'/                       BLOCK7
      END                                                               BLOCK8
C--------------------------------------------------------               BLOCK9
```

```
C-----------------------------------------------------------------------
C
      SUBROUTINE DAILY
C
C     CALLED SEPARATELY FOR EACH SUBAREA
C
      DIMENSION  NDPM(12),DPOLL(6),WMONTH(12),DPOLLQ(6),
     *     RPOLL(6),IMDATA(10),IDDATA(10),ARAIN(10),
     *     MPOLL(6),YPOLL(6),ARPOLL(6)
      COMMON SRRAIN,SRRUNO,SROVFL,SRTRTD,SRSTOR,SRPOLL(6),SNRTRT,
     *       STMAX,TRRATE,COEFX,RFAC,QCRO(7),WNAME(5),WASHED(5),
     *       QCTR(7),FREQ(2),SNRRAI,SNROVF,NSUB,NSUBS,IOQUAL,
     *       IPRINT,N1,N5,N6,N7,READNO,WRITNO,MSTART,YSTART,ERFLAG
C
      COMMON  /QOPTS/  QOPT(5,4)
      INTEGER*4  YDATA,YDATAP,DDATAP,YPRES,DPRES,YPREV,
     *         YDATLQ,DDATLQ,NCARD,DDATA,MSTART,YSTART,
     *          MDATLQ,YBEGIN,NYEAR,READNO,WRITNO,ERFLAG,
     *         ANRRAI,ANROVF,SNRRAI,SNROVF
      REAL*8  YRAIN,YRUNOF,YTRTD,YOVFL,YPOLL,DTRTD,DOVFL,RAIN,DLATQ,
     *        RRAIN,RRUNOF,RTRTD,ROVFL,RPOLL,RSTOR,DLQ,
     *        ARRAIN,ARRUNO,AROVFL,ARTRTD,ARPOLL,ARSTOR,ANRTRT,
     *        SRRAIN,SRRUNO,SROVFL,SRTRTD,SRPOLL,SRSTOR,SNRTRT
      REAL*8  MRAIN,MRUNOF,MTRTD,MOVFL,MSTOR,MPOLL,
     *        NDTRTD,NMTRTD,NYTRTD,NRTRTD
      DATA WMONTH/'JAN.','FEB.','MAR.','APR.',' MAY','JUNE','JULY',
     *           'AUG.','SEPT','OCT.','NOV.','DEC.'/
      DATA NDPM/31,28,31,30,31,30,31,31,30,31,30,31/
C
C     DEFINITION OF PRINCIPAL VARIABLES
C     (AN INITIAL 'N' INDICATES NUMBER OF DAYS)
C
C         DESCRIPTION           DAILY     MONTHLY   YEARLY    SUBAREA
C                                                              RUN
C
C         CURRENT DATA DATE     DDATA     MDATA     YDATA       -
C         PREVIOUS DATE         DDATAP    MDATAP    YDATAP      -
C           OR ALSO               -       MPREV     YPREV       -
C         PRESENT DATE          DPRES     MPRES     YPRES       -
C         RAIN, IN.             DRAIN     MRAIN     YRAIN     RRAIN
C         RAIN, DAYS            NDRAIN    NMRAIN    NYRAIN    NRRAIN
C         RUNOFF, MGAL          DRUNOF    MRUNOF    YRUNOF    RRUNOF
C         RUNOFF, DAYS            -         -         -         -
C         TREATED, MGAL         DTRTD     MTRTD     YTRTD     RTRTD
C         TREATED, DAYS         NDTRTD    NMTRTD    NYTRTD    NRTRTD
C         OVERFLOW, MGAL        DOVFL     MOVFL     YOVFL     ROVFL
C         OVERFLOW, DAYS        NDOVFL    NMOVFL    NYOVFL    NROVFL
C         MAX STORAGE, MGAL     DSTOR     MSTOR     YSTOR     RSTOR
C         POLLUT. LOAD, KLB     DPOLL     MPOLL     YPOLL     RPOLL
C         TREAT RATE, MGAL/DAY  TRRATE      -         -         -
C
C?????OPEN LATERAL INFLOW FILE,OUTPUTFILES, RAINFILE IF REQUIRED
C
C     IF DATA IS TO BE READ FROM DISK INITIALIZE POINTER
      IF (N1 .NE. 0) REWIND N1
C
C
C         READ AND SCREEN FIRST YEAR DATA CARD
      READ(N5,49) YDATA,NCARD
   49 FORMAT (6X,I4,6X,I4)
```

```
      IF (YSTART .EQ.0) GO TO 1148                                      DAILY60
      IF (YDATA.LT.YSTART) GO TO 1146                                   DAILY60
      GO TO 1148                                                        DAILY60
 1146 WRITE (6,1147) YDATA,YSTART                                       DAILY60
 1147 FORMAT (1X,'COMPUTATION STOPPED.  CALENDAR YEAR OF DATA(',I4,     DAILY60
     *       ') IS BEFORE SPECIFIED STARTING YEAR(',I4,')')             DAILY60
      ERFLAG = 1                                                        DAILY60
      GO TO 90909                                                       DAILY60
 1148 CONTINUE                                                          DAILY60
C                                                                       DAILY60
      IF (YDATA .EQ. 9999) GO TO 8                                      DAILY61
      GO TO 9                                                           DAILY62
    8 WRITE (WRITNO,18)                                                 DAILY63
   18 FORMAT (1X,'FIRST YEAR DATA CARD CONTAINS 9999,',                 DAILY64
     *       ' INDICATING NO RAIN INPUT *ERROR*')                       DAILY65
      ERFLAG  = 1                                                       DAILY66
      GO TO 90909                                                       DAILY67
C                                                                       DAILY68
C         READ AND SCREEN FIRST RAIN DATA (RAIN IN 0.01 IN/HR)          DAILY69
C                                                                       DAILY70
    9 READ(N5,50) (IMDATA(L),IDDATA(L),ARAIN(L),L=1,10)                 DAILY71
   50 FORMAT (10(2I2,F4.2))                                             DAILY72
      MDATA = IMDATA(1)                                                 DAILY73
      DDATA = IDDATA(1)                                                 DAILY74
      RAIN  = ARAIN(1)                                                  DAILY75
      IF (YDATA .EQ. 4*IFIX(0.001+0.25*(FLOAT(YDATA))) .AND.            DAILY76
     *    MDATA .EQ. 2 .AND. DDATA .EQ. 29)  GO TO 7                    DAILY77
      IF (DDATA .LE. NDPM(MDATA) .AND. DDATA .GT. 0)  GO TO 7           DAILY78
    5 WRITE(WRITNO,61)  YDATA,MDATA,DDATA                               DAILY79
   61 FORMAT(1H0,'LAST (PROBLEM?) DATA CARD READ CONTAINS',             DAILY80
     *       ' YEAR,MONTH,DAY =',2(I2,'/'),I5)                          DAILY81
      ERFLAG  = 1                                                       DAILY82
      GO TO 90909                                                       DAILY83
C                                                                       DAILY84
C          OTHER PRELIMINARY INITIALIZATION                             DAILY85
C                                                                       DAILY86
C     ASSIGN MSTART AND YSTART IF VALUES ARE ZERO.                      DAILY87
C                                                                       DAILY88
    7 IF (MSTART.NE.0.AND.YSTART.NE.0) GO TO 7000                       DAILY89
      MSTART = 7                                                        DAILY90
      YSTART = YDATA                                                    DAILY91
      IF (MDATA.LT.MSTART) YSTART = YSTART - 1                          DAILY92
C                                                                       DAILY93
 7000 YPRES = YSTART                                                    DAILY94
      NYEAR = 0                                                         DAILY95
      ARRAIN = 0.0                                                      DAILY96
      ANRRAI = 0                                                        DAILY97
      ARRUNO = 0.0                                                      DAILY98
      AROVFL = 0.0                                                      DAILY99
      ARTRTD = 0.0                                                      DAILY100
      ANROVF = 0                                                        DAILY101
      ANRTRT = 0                                                        DAILY102
      ARSTOR = 0.0                                                      DAILY103
      DO 12 K=1,6                                                       DAILY104
   12 ARPOLL(K) = 0.0                                                   DAILY105
        MPRES = MSTART                                                  DAILY106
        MPREV = MPRES                                                   DAILY107
        DPRES = 1                                                       DAILY108
        YDATAP = YDATA                                                  DAILY109
        MDATAP = MSTART                                                 DAILY110
```

```
         DDATAP = 1                                                     DAILY111
         RRAIN  = 0.0                                                   DAILY112
         NRRAIN = 0                                                     DAILY113
         RRUNOF = 0.0                                                   DAILY114
         RTRTD  = 0.0                                                   DAILY115
         NRTRTD = 0.0                                                   DAILY116
         ROVFL  = 0.0                                                   DAILY117
         NROVFL = 0                                                     DAILY118
         RSTOR  = 0.0                                                   DAILY119
      DO 20  K=1,6                                                      DAILY120
   20    RPOLL(K) = 0.0                                                 DAILY121
         DSTOR  = 0.0                                                   DAILY122
         DLATQ = 0.0                                                    DAILY123
         DLQ = 0.0                                                      DAILY123
         NDAT = 1                                                       DAILY124
         NGAP = 10                                                      DAILY125
         IGAP = 1                                                       DAILY126
         IEND = 0                                                       DAILY127
         IYCNT = 0                                                      DAILY128
      INFLAG = 0                                                        DAILY129
      YBEGIN = YPRES                                                    DAILY130
      WRITE(WRITNO,69)  MDATA,DDATA,YDATA                               DAILY131
   69 FORMAT(//,1H ,4X,'DATE OF FIRST RAIN IS ',2(I2,'/'),              DAILY132
     *       I5)                                                        DAILY133
C                                                                       DAILY134
C                                                                       DAILY135
C          WRITE:  TABLE HEADINGS FOR SUBAREA SUMMARY                   DAILY136
C                                                                       DAILY137
      IF (IPRINT .NE. 4)  GO TO 695                                     DAILY138
      WRITE(WRITNO,690)                                                 DAILY139
  690 FORMAT(1H1,///,6X,4X,42X,' SUMMARY')                              DAILY140
      WRITE(WRITNO,692)  WASHED,(WNAME(I),I=1,5),(QOPT(L,IOQUAL),L=1,5) DAILY141
  692 FORMAT(//,40X, 5A4,10X,5A4,/,                                     DAILY142
     11X,124('-'),/,90X,5A4,/,82X,'POLLUTANT LOAD, THOUSANDS OF POUNDS' DAILY143
     2,/,5X,' RAIN  RAIN   RUNOFF  OVERFLOW  TREATED  OVERFL  ',        DAILY144
     3'TREAT  MAX STORAGE  ',50('-'),/,05X,'   IN.  DAYS    MGAL',      DAILY145
     *'     MGAL      ',                                                DAILY146
     4'MGAL     DAYS   DAYS       MGAL ',8X,' BOD     SS       VSS ',   DAILY147
     5 3X, 'TOT N   TOT P  OTHERS',/,5X,'  ----  ----',                 DAILY148
     62X ,'-------  --------  -------  ------  -----  -----------',     DAILY149
     7 3X,6(' -------'))                                                DAILY150
C                                                                       DAILY151
C                                                                       DAILY152
C          WRITE:  TABLE HEADINGS FOR YEARLY SUMMARY                    DAILY153
C                                                                       DAILY154
  695 IF (IPRINT .NE. 3)  GO TO 1000                                    DAILY155
      WRITE(WRITNO,71)  FREQ                                            DAILY156
   71 FORMAT(1H1,///,6X,4X,42X,2A4,' SUMMARY')                          DAILY157
      IF (NDPM(MPRES) .EQ. 29)  WRITE(WRITNO,72)                        DAILY158
   72 FORMAT(1H+,14X,'(LEAP YEAR)')                                     DAILY159
      WRITE(WRITNO,60)  WASHED,(WNAME(I),I=1,5),(QOPT(L,IOQUAL),L=1,5)  DAILY160
   60 FORMAT(//,40X, 5A4,10X,5A4,/,                                     DAILY161
     11X,124('-'),/,90X,5A4,/,82X,'POLLUTANT LOAD, THOUSANDS OF POUNDS' DAILY162
     2,/,1X,'WTR.  RAIN  RAIN   RUNOFF  OVERFLOW  TREATED  OVERFL  ',   DAILY163
     3'TREAT  MAX STORAGE  ',50('-'),/,01X,'YEAR   IN.  DAYS    MGAL',  DAILY164
     *'     MGAL      ',                                                DAILY165
     4'MGAL     DAYS   DAYS       MGAL ',8X,' BOD     SS       VSS ',   DAILY166
     5 3X, 'TOT N   TOT P  OTHERS',/,1X,'----  ----  ----',             DAILY167
     62X ,'-------  --------  -------  ------  -----  -----------',     DAILY168
     7 3X,6(' -------'))                                                DAILY169
```

```
C
 1000 CONTINUE
C
C          START A NEW WATER YEAR.  FIRST INITIALIZE
C
        IGAP = 1
        MPREV = MSTART - 1
        IF (IEND .EQ. 1) GO TO 900
        YPREV = YDATA
        YRAIN  = 0.0
        NYRAIN = 0
        YRUNOF = 0.0
        YTRTD  = 0.0
        NYTRTD = 0.0
        YOVFL  = 0.0
        NYOVFL = 0
        YSTOR  = 0.0
      DO 110  K=1,6
  110   YPOLL(K) = 0.0
C
C
C         WRITE:  TABLE HEADINGS FOR MONTHLY SUMMARY
C
      IF (IPRINT .NE. 2)  GO TO 2000
      WRITE(WRITNO,1071)  YPRES,FREQ
 1071 FORMAT(1H1,///,6X,I4,42X,2A4,' SUMMARY')
      IF (NDPM(MPRES) .EQ. 29)  WRITE(WRITNO,72)
      WRITE(WRITNO,1060)  WASHED,(WNAME(I),I=1,5),(QOPT(L,IOQUAL),L=1,5)
 1060 FORMAT(//,40X, 5A4,10X,5A4,/,
     11X,124('-'),/,90X,5A4,/,82X,'POLLUTANT LOAD, THOUSANDS OF POUNDS'
     2,/,1X,'MONTH RAIN  RAIN   RUNOFF  OVERFLOW  TREATED  OVERFL  ',
     3'TREAT  MAX STORAGE  ',50('-'),/,08X,'IN.  DAYS    MGAL     MGAL
     4   MGAL     DAYS   DAYS      MGAL ',8X,' BOD     SS      VSS ',
     5 3X, 'TOT N   TOT P  OTHERS',/,1X,'----  ----  ----',
     62X ,'-------  --------  -------  ------  -----  -----------',
     7 3X,6(' -------'))
C
 2000 CONTINUE
C
C           START A NEW MONTH.  FIRST INITIALIZE
C
        MRAIN  = 0.0
        NMRAIN = 0
      DO 230  K=1,6
  230   MPOLL(K) = 0.0
        NMOVFL = 0
        NMTRTD = 0.0
        MSTOR  = 0.0
        MRUNOF = 0.0
        MOVFL  = 0.0
        MTRTD  = 0.0
        IHEADG = 1
C
C          ADJUST NDPM(2) (=NO. DAYS IN FEB.) FOR LEAP YEAR
      IF (MPRES .NE. 2)  GO TO 130
        NDPM(2) = 28
      IF(YPRES .NE. 4*IFIX(0.001+0.25*(FLOAT(YPRES))))  GO TO 130
        NDPM(2) = 29
  130 CONTINUE
C
```

```
C          WRITE:  TABLE HEADINGS FOR DAILY SUMMARY
C
      IF (IPRINT .NE. 1)  GO TO 3000
      WRITE(WRITNO,2071)  WMONTH(MPRES),YPRES,FREQ
 2071 FORMAT(1H1,///,5X,A4,1X,I4,38X,2A4,' SUMMARY')
      IF (NDPM(MPRES) .EQ. 29)  WRITE(WRITNO,72)
      WRITE(WRITNO,2060)  WASHED,(WNAME(I),I=1,5),(QOPT(L,IOQUAL),L=1,5)
 2060 FORMAT(//,40X, 5A4,10X,5A4,/,
     11X,124('-'),/,90X,5A4,/,82X,'POLLUTANT LOAD, THOUSANDS OF POUNDS'
     2,/,1X,'DAY   RAIN  RAIN   RUNOFF  OVERFLOW  TREATED  OVERFL  ',
     3'TREAT  MAX STORAGE  ',50('-'),/,08X,'IN.  DAYS    MGAL     MGAL
     4   MGAL     DAYS   DAYS       MGAL ',8X,' BOD      SS      VSS ',
     5 3X, 'TOT N   TOT P  OTHERS',/,1X,'----  ----  ----',
     62X ,'-------  --------  -------  ------  -----  -----------',
     7 3X,6(' -------'))
C
 3000 CONTINUE
C
C          START A NEW DAY.  FIRST INITIALIZE
C
        NDRAIN = 0
        DRAIN  = 0.0
        DRUNOF = 0.0
        DOVFL  = 0.0
        DTRTD  = 0.0
        NDOVFL = 0
        NDTRTD = 0
      DO 330  K=1,6
  330   DPOLL(K) = 0.0
C
C          READ FROM DISK  LATERAL INFLOW, IF PRESCRIBED,
C          CHECK INPUT DATES MATCH FOR RAIN AND LATERAL INFLOW,
C
      IF (N1 .EQ. 0)  GO TO 380
      IF (INFLAG .EQ. 1) GO TO 370
      READ(N1,374)  YDATLQ,MDATLQ,DDATLQ,DLQ,(DPOLLQ(K),K=1,6)
  374 FORMAT(1X,I4,1X,I2,1X,I2,1X,F8.1,6(1X,F8.0))
C
  370 CONTINUE
      IF (YPRES .EQ. YDATLQ .AND. MPRES .EQ. MDATLQ .AND.
     *    DPRES .EQ. DDATLQ)  GO TO 371
      DLATQ = 0
      INFLAG = 1
      GO TO 380
  371 INFLAG = 0
      DLATQ = DLQ
C
C
C          COMPUTE RUNOFF, STORAGE
C
  380 IF (YPRES.EQ.YDATA.AND.MPRES.EQ.MDATA.AND.
     *    DPRES.EQ.DDATA) IGAP = 0
      IF(IGAP .NE. 0)  GO TO 409
C          FOR DAYS WITH RAIN DATA ONLY
        DRAIN=RAIN*RFAC
      IF (DRAIN .EQ. 0.0)  GO TO 409
        NDRAIN = 1
        NMRAIN = NMRAIN + 1
        NYRAIN = NYRAIN + 1
        NRRAIN = NRRAIN + 1
        MRAIN = MRAIN + DRAIN                                           DAILY289
        YRAIN = YRAIN + DRAIN                                           DAILY290
        RRAIN = RRAIN + DRAIN                                           DAILY291
        DRUNOF = COEFX*DRAIN                                            DAILY292
        MRUNOF = MRUNOF + DRUNOF                                        DAILY293
        YRUNOF = YRUNOF + DRUNOF                                        DAILY294
        RRUNOF = RRUNOF + DRUNOF                                        DAILY295
C          ADD IN THE LATERAL INFLOW                                    DAILY296
  409   STORA = DSTOR + DRUNOF + DLATQ                                  DAILY297
C                                                                       DAILY298
C          COMPUTE STORAGE, WITHDRAWAL (TREATMENT), OVERFLOW            DAILY299
C                                                                       DAILY300
C                                                                       DAILY301
  440   DSTOR = STORA - TRRATE                                          DAILY302
      IF (DSTOR .GT. 0.0)  GO TO 450                                    DAILY303
        DSTOR = 0.0                                                     DAILY304
C                                                                       DAILY305
  450   DTRTD = STORA - DSTOR                                           DAILY306
      IF (TRRATE .EQ. 0.0)  GO TO 460                                   DAILY307
        NDTRTD = DTRTD/TRRATE                                           DAILY308
        NMTRTD = NMTRTD + NDTRTD                                        DAILY309
        NYTRTD = NYTRTD + NDTRTD                                        DAILY310
        NRTRTD = NRTRTD + NDTRTD                                        DAILY311
        MTRTD = MTRTD + DTRTD                                           DAILY312
        YTRTD = YTRTD + DTRTD                                           DAILY313
        RTRTD = RTRTD + DTRTD                                           DAILY314
C                                                                       DAILY315
  460   STOROV = DSTOR - STMAX                                          DAILY316
      IF (STOROV .LE. 0.0)  GO TO 470                                   DAILY317
        NMOVFL = NMOVFL + 1                                             DAILY318
        NYOVFL = NYOVFL + 1                                             DAILY319
        NROVFL = NROVFL + 1                                             DAILY320
        NDOVFL = 1                                                      DAILY321
        DOVFL = STOROV                                                  DAILY322
        MOVFL = MOVFL + STOROV                                          DAILY323
        YOVFL = YOVFL + STOROV                                          DAILY324
        ROVFL = ROVFL + STOROV                                          DAILY325
        DSTOR = STMAX                                                   DAILY326
 470  IF (DSTOR .GT. MSTOR)  MSTOR = DSTOR                              DAILY327
      IF (DSTOR .GT. YSTOR)  YSTOR = DSTOR                              DAILY328
      IF (DSTOR .GT. RSTOR)  RSTOR = DSTOR                              DAILY329
C                                                                       DAILY330
C          COMPUTE POLLUTANT LOADS                                      DAILY331
C                                                                       DAILY332
      GO TO (480,500,520,500),IOQUAL                                    DAILY333
C                IOQUAL = 1 ;  LOAD BASED ON TOTAL R.O.                 DAILY334
  480 DO 490  K=1,6                                                     DAILY335
  490   DPOLL(K) = DRUNOF*QCRO(K+1)                                     DAILY336
C                                                                       DAILY337
      GO TO 540                                                         DAILY338
C                IOQUAL = 2;  LOAD FROM OVERFLOW ONLY                   DAILY339
C                IOQUAL = 4;  LOAD FROM O'FLOW & WW TREATMENT           DAILY340
  500 DO 510  K=1,6                                                     DAILY341
  510   DPOLL(K) = DOVFL*QCRO(K+1)                                      DAILY342
C                                                                       DAILY343
      IF (IOQUAL .NE. 4)  GO TO 540                                     DAILY344
C                 IOQUAL = 3;  LOAD FROM WW TREATMENT ONLY              DAILY345
C                IOQUAL = 4;  LOAD FROM O'FLOW & WW TREATMENT           DAILY346
  520 DO 530  K=1,6                                                     DAILY347
  530   DPOLL(K) = DTRTD*QCTR(K+1) + DPOLL(K)                           DAILY348
```

```
C
  540 DO 550  K=1,6
        MPOLL(K) = MPOLL(K) + DPOLL(K)
        YPOLL(K) = YPOLL(K) + DPOLL(K)
  550   RPOLL(K) = RPOLL(K) + DPOLL(K)
C
C           END OF A DAY
C
C
C           WRITE OUTPUT FILE (N6) TO DISK FOR WITHDRAWALS, IF N6 .GT. 0
C
      IF (N6 .EQ. 0)  GO TO 551
      IF (DTRTD .EQ. 0) GO TO 551
      WRITE(N6,374)  YPRES,MPRES,DPRES,DTRTD,(DPOLL(K),K=1,6)
C
      GO TO 552
C
C           WRITE OUTPUT FILE (N7) TO DISK FOR OVERFLOWS, IF N7 .GT. 0
C
  551 IF (N7 .EQ. 0) GO TO 552
      IF (DOVFL .EQ. 0) GO TO 552
      WRITE(N7,374)  YPRES,MPRES,DPRES,DOVFL,(DPOLL(K),K=1,6)
  552 CONTINUE
C
C           PRINT DAILY INFORMATION
C
        IHEADG = 1
      IF (DRAIN .EQ. 0.0 .AND. DOVFL .EQ. 0.0 .AND. DTRTD .EQ. 0.0)
     *  IHEADG = 0
      IF (IHEADG .EQ. 0)  GO TO 580
C
      IF (IPRINT .EQ. 1)  WRITE(WRITNO,62)DPRES,DRAIN,NDRAIN,DRUNOF,
     *      DOVFL,DTRTD,NDOVFL,NDTRTD,DSTOR,(DPOLL(K),K=1,6)
   62 FORMAT(1H ,I3,F7.2,I5,F10.1,2F9.1,2X,I5,F9.1,F12.1,4X,6F8.0)
C           TEST FOR REMAINING DATA GAP
  580 IF (IGAP .NE. 0)  GO TO 600
C
C     READ IN NEXT RAIN DATA AND CHECK FOR END OF YEAR'S DATA
C
      NDAT = NDAT + 1
      IF  (NDAT .LE. NGAP) GO TO 554
      NCARD = NCARD-1
      IF (NCARD .NE. 0) GO TO 553
      READ(N5,49) YDATA,NCARD
      IF (YDATA .EQ. 9999) GO TO 555
C
C         READ AND SCREEN  RAIN DATA (RAIN IN 0.01 IN/HR)
C
  553 READ(N5,50) (IMDATA(L),IDDATA(L),ARAIN(L),L=1,10)
      DO 381 L=1,10
  381 IF (IMDATA(L) .EQ. 0.OR.ARAIN(L) .EQ. 0) GO TO 1107
      NDAT = 1
      NGAP = 10
      GO TO 554
 1107 NGAP = L-1
      NDAT = 1
  554 MDATA = IMDATA(NDAT)
      DDATA = IDDATA(NDAT)
      RAIN  = ARAIN(NDAT)
  555 IF (YDATA .NE. 9999) GO TO 556
```

```
      YDATA = YDATAP
      MDATA = MSTART
      DDATA = 1
      RAIN = 0
      IEND = 1
      GO TO 590
  556 IF (DDATA .GT. NDPM(MDATA) .OR. DDATA .LE. 0)  GO TO 5
C          CHECK IF DATA DATE IS OUT OF SEQUENCE
      IF (MDATAP.EQ.12.AND.MDATA.EQ.1) YDATA=YDATA+1
  586 IF (YDATA - YDATAP)  589,587,590
  587 IF (MDATA - MDATAP)  589,588,590
  588 IF (DDATA .GT. DDATAP)  GO TO 590
C          NEW DATA DATE IS OUT OF SEQUENCE
  589 WRITE(WRITNO,73)  MDATA,DDATA,YDATA
   73 FORMAT(1H0,'LAST DATA CARD FOR',2(I2,'/'),I4,' IS OUT OF',
     *' SEQUENCE')
      ERFLAG  = 1
      GO TO 90909
  590   YDATAP = YDATA
        MDATAP = MDATA
        DDATAP = DDATA
        IGAP = 1
C
C          CALENDAR:  INCREMENT PRESENT DATE BY ONE DAY
C
  600   DPRES = DPRES + 1
C       INITIALIZE MPREV
        MPREV = MPRES
      IF (DPRES .LE. NDPM(MPRES))  GO TO 650
        MPRES = MPRES + 1
        DPRES = 1
      IF (MPRES .LE. 12)  GO TO 650
        YPRES = YPRES + 1
        MPRES = 1
C          IS DATA GAP CLOSED?
  650 IF (YPRES .EQ. YDATA .AND. MPRES .EQ. MDATA .AND.
     *    DPRES .EQ. DDATA)  IGAP = 0
C
 6666 IF (DPRES .NE. 1)  GO TO 3000
C
C          END OF A MONTH.  PRINT MONTHLY SUMMARY
C
      IF (IPRINT.EQ.2) WRITE(WRITNO,63)MPREV,MRAIN,NMRAIN,
     *      MRUNOF,MOVFL,MTRTD,NMOVFL,NMTRTD,MSTOR,(MPOLL(K),K=1,6)
   63 FORMAT(1H,/,I3,F7.2,I5,F10.1,
     *     2F9.1,2X,'*',I4,2X,F7.1,F12.1,'*',3X,6F8.0)
      IF (IPRINT .LT. 2) WRITE(WRITNO,67)  MRAIN,NMRAIN,MRUNOF,MOVFL,
     *             MTRTD,NMOVFL,NMTRTD,MSTOR,(MPOLL(K),K=1,6)
   67 FORMAT(///1X,'MONTHLY TOTAL (OR MAX*)'//,1H ,3X,F7.2,I5,F10.1,
     *     2F9.1,3X,I4,2X,F7.1,F12.1,'*',3X,6F8.0)
 7777 IF (MPRES .NE. MSTART)  GO TO 2000
C
C       END OF A WATER YEAR (7/01-6/30 DEFAULT).  PRINT YEARLY SUMMARY
C
      IF (IPRINT .NE. 3) GO TO 153
      IF (IYCNT .LE. 15) GO TO 152
      WRITE(WRITNO,71) FREQ
      WRITE(WRITNO,60) WASHED,(WNAME(I),I=1,5),(QOPT(L,IOQUAL),L=1,5)
  152 WRITE(WRITNO,64)YPREV,YRAIN,NYRAIN,YRUNOF,YOVFL,
     *      YTRTD,NYOVFL,NYTRTD,YSTOR,(YPOLL(K),K=1,6)
   64 FORMAT(1H,/,I5,F7.2,I4,F10.1,                                      DAILY469
     *     2F9.1,2X,'*',I4,2X,F7.1,F12.1,'*',3X,6F8.0)                   DAILY470
      IYCNT = IYCNT + 1                                                  DAILY471
C                                                                        DAILY472
  153 IF (IPRINT .LT. 3) WRITE(WRITNO,68)  YRAIN,NYRAIN,YRUNOF,YOVFL,    DAILY473
     *               YTRTD,NYOVFL,NYTRTD,YSTOR,(YPOLL(K),K=1,6)          DAILY474
   68 FORMAT(///1X,'WATER YEAR TOTAL (OR MAX*)',                         DAILY475
     *     //,1H ,3X,F7.2,I5,                                            DAILY476
     *     F10.1,2F9.1,3X,I4,2X,F7.1,F12.1,'*',3X,6F8.0)                 DAILY477
C                                                                        DAILY478
      NYEAR = NYEAR +1                                                   DAILY479
C                                                                        DAILY480
 8888 GO TO 1000                                                         DAILY481
C                                                                        DAILY482
C           CLOSE OFF OUTPUT FILES WITH 999'S                            DAILY483
 900  IF (N6.EQ.0) GO TO 8080                                            DAILY484
      WRITE(N6,65)                                                       DAILY485
 65   FORMAT(1X,3('9999999999'))                                         DAILY486
 8080 IF (N7.EQ.0) GO TO 8090                                            DAILY487
      WRITE(N7,65)                                                       DAILY488
 8090 CONTINUE                                                           DAILY489
C                                                                        DAILY490
C                                                                        DAILY491
C           PRINT:  SUMMARY AT END OF SUBAREA RUN                        DAILY492
C                                                                        DAILY493
      WRITE(WRITNO,79)  RRAIN,NRRAIN,RRUNOF,ROVFL,RTRTD,NROVFL,          DAILY494
     *                NRTRTD,RSTOR,(RPOLL(K),K=1,6)                      DAILY495
   79 FORMAT(///1X,'SUBAREA RUN TOTAL (OR MAX*)',                        DAILY496
     *  //,1H ,3X,F7.2,I5,F10.1,2F9.1,3X,                                DAILY497
     *  I4,2X,F7.1,F12.1,'*',3X,6F8.0)                                   DAILY498
C                                                                        DAILY499
C     CALCULATE SUBAREA AVERAGES                                         DAILY500
C                                                                        DAILY501
      ARRAIN = RRAIN  / NYEAR                                            DAILY502
      ANRRAI = NRRAIN / NYEAR                                            DAILY503
      ARRUNO = RRUNOF / NYEAR                                            DAILY504
      AROVFL = ROVFL  / NYEAR                                            DAILY505
      ARTRTD = RTRTD  / NYEAR                                            DAILY506
      ANRTRT = NRTRTD / NYEAR                                            DAILY507
      ANROVF = NROVFL / NYEAR                                            DAILY508
      IF (RSTOR .GT. ARSTOR) ARSTOR = RSTOR                              DAILY509
      DO 934 K=1,6                                                       DAILY510
  934 ARPOLL(K) = RPOLL(K) / NYEAR                                       DAILY511
C                                                                        DAILY512
      WRITE(WRITNO,935) NYEAR,YBEGIN,YPREV,ARRAIN,ANRRAI,ARRUNO,AROVFL, DAILY513
     *     ARTRTD,ANROVF,ANRTRT,ARSTOR,(ARPOLL(K),K=1,6)                 DAILY514
  935 FORMAT(1H,///,1X,'          AVERAGE ANNUAL SUBAREA VALUES USING', DAILY515
     *     I3,2X,20HYEARS OF RECORD --- ,I5,' TO ',I4,/,1X,95('-'),      DAILY516
     *     //,4X,F7.2,I5,F10.1,2F9.1,3X,I4,2X,F7.1,F12.1,'*',3X,6F8.0) DAILY517
C                                                                        DAILY518
C      CALCULATE CUMMULATIVE SUBAREA AVERAGES                            DAILY519
C                                                                        DAILY520
      SRRAIN = ARRAIN + SRRAIN                                           DAILY521
      SNRRAI = ANRRAI + SNRRAI                                           DAILY522
      SRRUNO = ARRUNO + SRRUNO                                           DAILY523
      SROVFL = AROVFL + SROVFL                                           DAILY524
      SRTRTD = ARTRTD + SRTRTD                                           DAILY525
      SNROVF = ANROVF + SNROVF                                           DAILY526
      SNRTRT = ANRTRT + SNRTRT                                           DAILY527
      IF (ARSTOR .GT. SRSTOR) SRSTOR = ARSTOR                            DAILY528
      DO 937 K=1,6                                                      DAILY529
  937 SRPOLL(K) = ARPOLL(K) + SRPOLL(K)                                 DAILY530
C                                                                       DAILY531
      IF (NSUB .NE. NSUBS) GO TO 990                                    DAILY532
      SRRAIN = SRRAIN / NSUBS                                           DAI.LY533
      SNRRAI = SNRRAI / NSUBS                                           DAILY534
      SNROVF = SNROVF / NSUBS                                           DAILY535
      SNRTRT = SNRTRT / NSUBS                                           DAILY536
C                                                                       DAILY537
C           PRINT FINAL SUMMARY AT END OF RUN                           DAILY538
C                                                                       DAILY539
      WRITE(WRITNO,938) NSUBS,NYEAR,YBEGIN,YPREV                        DAILY540
  938 FORMAT(1H1,///,1X,T50,'RUN          SUMMARY',//,16X,'CUMULATIVE ',DAILY541
     *     'AVERAGE ANNUAL VALUES FOR ',I4,                             DAILY542
     *     ' SUBAREAS, USING',I4,' YEARS OF RECORD --- ',I5,' TO ',I4)  DAILY543
      WRITE(WRITNO,9381) (QOPT(L,IOQUAL),L=1,5)                         DAILY544
 9381 FORMAT(1H ,                                                       DAILY545
     1124('-'),/,90X,5A4,/,82X,'POLLUTANT LOAD, THOUSANDS OF POUNDS'    DAILY546
     2,/,1X,4X,' RAIN RAIN  RUNOFF  OVERFLOW  TREATED  OVERFL  ',       DAILY547
     3'TREAT  MAX STORAGE  ',50('-'),/,01X,4X,'   IN.  DAYS    MGAL',   DAILY548
     *'     MGAL      ',                                                DAILY549
     4'MGAL     DAYS   DAYS      MGAL ',8X,' BOD     SS      VSS ',     DAILY550
     5 3X, 'TOT N   TOT P  OTHERS',/,1X,4X,'  ----  ----',              DAILY551
     62X ,'-------  --------  -------  ------  -----  -----------',     DAILY552
     7 3X,6(' -------'))                                                DAILY553
      WRITE(WRITNO,9382) SRRAIN,SNRRAI,SRRUNO,SROVFL,SRTRTD,(SRPOLL(K), DAILY554
     *      K=1,6)                                                      DAILY555
 9382 FORMAT(//,4X,F7.2,'$',I4,'$',3F9.1,5X,'-',7X,'-',9X,'-',8X,6F8.0, DAILY556
     *      /////,5X,                                                   DAILY557
     *      '$  :  REFERS TO SUBAREA AVERAGE VALUES AS DISTINGUISHED ', DAILY558
     *      'FROM SUBAREA TOTAL VALUES.')                               DAILY559
C                                                                       DAILY560
  990 CONTINUE                                                          DAILY561
C                                                                       DAILY562
C?????CLOSE RAIN,AND OUTPUT FILES IF REQUIRED                           DAILY563
C                                                                       DAILY564
C     THE REWIND STATEMENTS SERVE TO CLOSE AND UPDATE ALL EXTERNAL      DAILY565
C     FILES AT END OF SUBAREA                                           DAILY566
C                                                                       DAILY567
      IF (N5 .NE. READNO)  REWIND N5                                    DAILY568
      IF (N6 .GT. 0)  REWIND N6                                         DAILY569
      IF (N7 .GT. 0)  REWIND N7                                         DAILY570
      IF (N1 .NE. 0) REWIND N1                                          DAILY571
C                                                                       DAILY572
90909 RETURN                                                            DAILY573
      END                                                               DAILY574
C-----------------------------------------------------------------------DAILY575
```

```
C-----------------------------------------------------------------------MAIN 1
C                                                                       MAIN 2
C           THIS IS THE ABAG DATA CHECKING PROGRAM                      MAIN 3
C                                                                       MAIN 4
C                VERSION 1       JUNE  5,1979                           MAIN 5
C                                                                       MAIN 6
C      MAIN PROGRAM SEGMENT FOR ABAG MAC MODEL APPLICATIONS (J6098)     MAIN 7
C                                                                       MAIN 8
C                                                                       MAIN 9
C      DEVELOPER:  M.E.STRICKFADEN                                      MAIN 10
C      OWNER:      METCALF & EDDY, INC.,ENGINEERS                       MAIN 11
C                  1029 CORPORATION WAY                                 MAIN 12
C                  PALO ALTO, CA   94303                                MAIN 13
C      TELEPHONE:  (415) 964-7100                                       MAIN 14
C                                                                       MAIN 15
C-----------------------------------------------------------------------MAIN 16
      DIMENSION GAUSE(7,5),GQC(7,7),GWNAME(5),GAREA(6),CLIENT(5),       MAIN 17
     *          IMDATA(10),IDDATA(10),IRAIN(10)                         MAIN 18
      INTEGER*4 NSUBS,N5,NCRD,NIN,WRITNO,READNO,IPRINT,YDATA,NCARD,     MAIN 19
     *          GN1FLG,GN5FLG,GN6FLG,GN7FLG,GIQUAL                      MAIN 20
      REAL*4 AQUAL,ALAND,APARAM                                         MAIN 21
C??   CHECK THIRD ARRAY DIMENSION                                       MAIN 22
      COMMON /PARAM/ APARAM(3,10,25)                                    MAIN 23
C??   CHECK THIRD ARRAY DIMENSION                                       MAIN 24
      COMMON /LAND/ ALAND(10,7,25)                                      MAIN 25
C??   CHECK THIRD ARRAY DIMENSION                                       MAIN 26
      COMMON /QUAL/ AQUAL(8,12,25)                                      MAIN 27
      COMMON  NSUBS,READNO,WRITNO                                       MAIN 28
C                                                                       MAIN 29
C?????OPEN INPUT DATA FILE IF REQUIRED                                  MAIN 30
C                                                                       MAIN 31
C     LOGICAL UNIT DEFAULTS ARE SET FOR INPUT DATA, PRINTER, AND        MAIN 32
C     RAIN FILE, CHANGE NEXT LINES IF SYSTEM DEFAULTS ARE DIFFERENT     MAIN 33
C                                                                       MAIN 34
      READNO = 9                                                        MAIN 35
      WRITNO = 6                                                        MAIN 36
      NIN    = 1                                                        MAIN 37
      N5     = 2                                                        MAIN 38
C                                                                       MAIN 39
C     WRITE INITIAL HEADING                                             MAIN 40
C                                                                       MAIN 41
      WRITE(WRITNO,1)                                                   MAIN 42
 1    FORMAT(1H1,//,5X,'ABAG MAC DATA CHECKING PROGRAM (JUNE  5,1979)', MAIN 43
     *      ' SIMULATION STARTED',//////,5X,'ASSOCIATION OF BAY AREA',  MAIN 44
     *      ' GOVERNMENTS',T80,'METCALF & EDDY, INC.,ENGINEERS',/,T80,  MAIN 45
     *      '1029 CORPORATION WAY',/,T80,'P.O. BOX 10-046',/,T80,'PALO',MAIN 46
     *      ' ALTO, CA   94303',2(/////),30X,'DATA CHECKING PROGRAM ',  MAIN 47
     *      'FOR ABAG MAC MODEL APPLICATIONS',//)                       MAIN 48
C                                                                       MAIN 49
C     INITIALIZE APARAM(I,J,K) TO 0.0                                   MAIN 50
C                                                                       MAIN 51
      DO 37 I=1,3                                                       MAIN 52
         DO 370 J=1,10                                                  MAIN 53
C??   CHECK THIRD ARRAY DIMENSION                                       MAIN 54
            DO 3700 K=1,25                                              MAIN 55
               APARAM(I,J,K) = 0.0                                      MAIN 56
 3700       CONTINUE                                                    MAIN 57
 370     CONTINUE                                                       MAIN 58
 37   CONTINUE                                                          MAIN 59
C                                                                       MAIN 60
```

```
C                                                                       MAIN 61
C          READ NO. OF SUBAREAS,  PRINTING OPTION, USER HEADING,        MAIN 62
C          INPUT FILE NO., CARD CONSOLIDATION OPTION.                   MAIN 63
C                                                                       MAIN 64
   10 READ(READNO,100)NSUBS,APARAM(2,8,1),(APARAM(2,J,1),J=1,5),        MAIN 65
     *    APARAM(3,8,1),APARAM(2,9,1),APARAM(2,6,1),APARAM(2,7,1)       MAIN 66
  100 FORMAT(I2,2X,F2.0,4X,5A4,8X,F2.0,8X,F2.0,8X,F2.0,F4.0)            MAIN 67
C                                                                       MAIN 68
      NCRD = APARAM(2,9,1)                                              MAIN 69
      IF (APARAM(3,8,1).NE.0) GO TO 28                                  MAIN 70
      NIN = 0                                                           MAIN 71
 28   CONTINUE                                                          MAIN 72
C                                                                       MAIN 73
C      IF SUBAREA CARD CONSOLIDATION OPTION                             MAIN 74
C      IS CHOSEN READ AND STORE REFERENCE VARIABLES                     MAIN 75
C                                                                       MAIN 76
   20 IF (NCRD .NE. 1) GO TO 30                                         MAIN 77
      DO 25 L=2,8                                                       MAIN 78
         I=L-1                                                          MAIN 79
         READ(READNO,200) NSBCRD,(GAUSE(I,K),K=1,5),(GQC(I,K),K=1,7)    MAIN 80
         IF (NSBCRD .NE. L) GO TO 27                                    MAIN 81
  200    FORMAT(I2,5A4,2X,7F8.2)                                        MAIN 82
   25 CONTINUE                                                          MAIN 83
C                                                                       MAIN 84
      READ(READNO,200) NSBCRD,(GWNAME(I),I=1,5),(GAREA(I),I=1,6)        MAIN 85
      IF (NSBCRD .NE. 9) GO TO 27                                       MAIN 86
      READ(READNO,250)NSBCRD,GN1FLG,GN5FLG,GN6FLG,GN7FLG,GAKOVR,GSTMAX, MAIN 87
     *                 GTRATE,GRFAC,GIQUAL                              MAIN 88
  250 FORMAT (I2,I2,6X,3I2,8X,4F8.2,I1)                                 MAIN 89
      IF (NSBCRD .NE. 10) GO TO 27                                      MAIN 90
C                                                                       MAIN 91
      GO TO 30                                                          MAIN 92
   27 WRITE(WRITNO,270)                                                 MAIN 93
  270 FORMAT (1X,'IMPROPER NUMBER OF SUBAREA CARDS',                    MAIN 94
     *   ' OR CARD DECK DOES NOT START WITH 02')                        MAIN 95
      GO TO 9000                                                        MAIN 96
C                                                                       MAIN 97
C                                                                       MAIN 98
C                                                                       MAIN 99
C     IF NIN NOT EQUAL TO READNO OR 0 AND NCRD IS EQUAL TO  1 READ INPUTMAIN 100
C     RAINCARDS TO ESTABLISH DISC/TAPE FILE FOR REFERENCE.              MAIN 101
   30 IF (NIN .EQ. 0.OR.NIN .EQ. READNO) GO TO 34                       MAIN 102
C                                                                       MAIN 103
   31 READ(READNO,310) YDATA,NCARD                                      MAIN 104
  310 FORMAT(6X,I4,6X,I4)                                               MAIN 105
      IF ( YDATA .EQ. 9999) GO TO 33                                    MAIN 106
      DO 32 I=1,NCARD                                                   MAIN 107
         READ(READNO,320) (IMDATA(L),IDDATA(L),IRAIN(L),L=1,10)         MAIN 108
  320    FORMAT(10(2I2,I4))                                             MAIN 109
   32 CONTINUE                                                          MAIN 110
      GO TO 31                                                          MAIN 111
   33 CONTINUE                                                          MAIN 112
      REWIND NIN                                                        MAIN 113
C                                                                       MAIN 114
C                       PRELIMINARY INITIALIZATION                      MAIN 115
C                                                                       MAIN 116
C     INITIALIZE ALAND(I,J,K) TO 0.0                                    MAIN 117
C                                                                       MAIN 118
 34   DO 35 I=1,10                                                      MAIN 119
         DO 350 J=1,7                                                   MAIN 120
```

```
C??   CHECK THIRD ARRAY DIMENSION
            DO 3500 K=1,25
               ALAND(I,J,K) = 0.0
 3500       CONTINUE
 350     CONTINUE
 35   CONTINUE
C
C     INITIALIZE AQUAL(I,J,K) TO 0.0
C
      DO 36 I=1,8
         DO 360 J=1,12
C??   CHECK THIRD ARRAY DIMENSION
            DO 3600 K=1,25
               AQUAL(I,J,K) = 0.0
 3600       CONTINUE
 360     CONTINUE
 36   CONTINUE
C
C     READ TEMPCARD
C
 40   IF (NCRD .NE. 1) GO TO 50
      READ(READNO,400) NSBCRD
  400 FORMAT(I2)
      IF (NSBCRD .EQ. 1) GO TO 50
      WRITE(WRITNO,401)
 401  FORMAT(1X,'SUBAREA #1 CARD DECK DOES NOT START WITH 01')
      GO TO 9000
C
C          REPEAT ENTIRE PROGRAM BELOW FOR EACH OF THE 'NSUBS' SUBAREAS
C
C*****
 50   DO   80  NSUB=1,NSUBS
C
C        IF CARD CONSOLIDATION OPTION NOT EQUAL TO 1 SKIP TO
C        CONVENTIONAL READ STATEMENTS.
C
         IF (NCRD .NE. 1) GO TO 70
C
C        NOTE THE PROGRAM WILL BLOW UP IF RAIN DATA OCCURS BETWEEN
C        SUBAREA CARDS WHEN NCRD=1.
C
         BACKSPACE READNO
         READ (READNO,500) (ALAND(1,J,NSUB),J=1,5)
   500   FORMAT(2X,5A4)
         READ(READNO,400) NSBCRD
         IF (NSBCRD .NE. 99) GO TO 55
         I = 2
         GO TO 66
C
C        BEGIN LOOP TO ASSIGN SUBAREA PARAMETERS IF CONSOLIDATION
C        OPTION IS IN EFFECT.
C
  55     DO 65 I=2,10
            IF (NSBCRD-I) 57,60,62
C
C     CARD CONSOL.   NEGATIVE VALUE - DETERMINE WHETHER CARDS ARE
C     OUT OF ORDER OR WHETHER NEXT '01' CARD WAS READ
C
  57        IF (NSBCRD .EQ. 1) GO TO 58
            WRITE(WRITNO,570)
  570 FORMAT(1X,'INPUT CARDS OUT OF ORDER')                             MAIN 181
      GO TO 9000                                                        MAIN 182
C                                                                       MAIN 183
C     ASSIGN REST OF VARIABLES FROM GENERAL VARIABLE SET                MAIN 184
C                                                                       MAIN 185
   58 DO 59 J=I,10                                                      MAIN 186
         L = J - 1                                                      MAIN 187
         IF (J.LE.8) GO TO 582                                          MAIN 188
         IF (J.EQ.9) GO TO 584                                          MAIN 189
         IF (J.EQ.10) GO TO 586                                         MAIN 190
C                                                                       MAIN 191
  582    DO 5822 K=1,5                                                  MAIN 192
 5822    ALAND(J,K,NSUB) = GAUSE(L,K)                                   MAIN 193
         DO 5824 K=1,7                                                  MAIN 194
 5824    AQUAL(J,K,NSUB) = GQC(L,K)                                     MAIN 195
         GO TO 59                                                       MAIN 196
C                                                                       MAIN 197
  584    DO 5842 K=1,5                                                  MAIN 198
 5842    ALAND(9,K,NSUB) = GWNAME(K)                                    MAIN 199
         DO 5844 K=1,6                                                  MAIN 200
 5844    ALAND(10,K,NSUB) = GAREA(K)                                    MAIN 201
         GO TO 59                                                       MAIN 202
C                                                                       MAIN 203
  586    APARAM(3,6,NSUB) = GN1FLG                                      MAIN 204
         APARAM(3,7,NSUB) = GN5FLG                                      MAIN 205
         APARAM(3,9,NSUB) = GN6FLG                                      MAIN 206
         APARAM(3,10,NSUB) = GN7FLG                                     MAIN 207
         APARAM(3,1,NSUB) = GAKOVR                                      MAIN 208
         APARAM(3,3,NSUB) = GSTMAX                                      MAIN 209
         APARAM(3,4,NSUB) = GTRATE                                      MAIN 210
         APARAM(3,2,NSUB) = GRFAC                                       MAIN 211
         APARAM(3,5,NSUB) = GIQUAL                                      MAIN 212
   59 CONTINUE                                                          MAIN 213
      GO TO 74                                                          MAIN 214
C                                                                       MAIN 215
C  CARD CONSOL.  ZERO VALUE ASSIGN PARAMETERS FROM INPUT DATA           MAIN 216
C                                                                       MAIN 217
  60  IF (NSBCRD .LE. 8) GO TO 602                                      MAIN 218
      IF (NSBCRD .EQ. 9) GO TO 604                                      MAIN 219
      IF (NSBCRD .EQ.10) GO TO 606                                      MAIN 220
  602 BACKSPACE READNO                                                  MAIN 221
      READ (READNO,610) (ALAND(NSBCRD,K,NSUB),K=1,5),                   MAIN 222
     *     (AQUAL(NSBCRD,K,NSUB),K=1,7)                                 MAIN 223
      GO TO 61                                                          MAIN 224
C                                                                       MAIN 225
  604 BACKSPACE READNO                                                  MAIN 226
      READ (READNO,610) (ALAND(9,K,NSUB),K=1,5),(ALAND(10,K,NSUB),MAIN 227
     *K=1,6)                                                            MAIN 228
      GO TO 61                                                          MAIN 229
C                                                                       MAIN 230
  606 BACKSPACE READNO                                                  MAIN 231
      READ (READNO,611) APARAM(3,6,NSUB),APARAM(3,7,NSUB),              MAIN 232
     *  APARAM(3,9,NSUB),APARAM(3,10,NSUB),APARAM(3,1,NSUB),            MAIN 233
     *  APARAM(3,3,NSUB),APARAM(3,4,NSUB),APARAM(3,2,NSUB),             MAIN 234
     *  APARAM(3,5,NSUB)                                                MAIN 235
C                                                                       MAIN 236
   61 READ(READNO,400) NSBCRD                                           MAIN 237
  610 FORMAT(2X,5A4,2X,7F8.2)                                           MAIN 238
  611 FORMAT(2X,F2.0,6X,3F2.0,8X,4F8.2,F1.0,6X,F2.0)                    MAIN 239
      GO TO 65                                                          MAIN 240
```

```
C
C  CARD CONSOL.  POSITIVE VALUE ASSIGN VALUES FROM REFERENCE VARIABLES
C
   62        L = I - 1
             IF (I.LE.8) GO TO 622
             IF (I.EQ.9) GO TO 624
             IF (I.EQ.10) GO TO 626
C
  622        DO 6221 K=1,5
  6221          ALAND(I,K,NSUB) = GAUSE(L,K)
             DO 6222 K=1,7
  6222          AQUAL(I,K,NSUB) = GQC(L,K)
             GO TO 63
C
  624        DO 6242 K=1,5
  6242          ALAND(9,K,NSUB) = GWNAME(K)
             DO 6244 K=1,6
  6244          ALAND(10,K,NSUB) = GAREA(K)
             GO TO 63
C
  626        APARAM(3,6,NSUB) = GN1FLG
             APARAM(3,7,NSUB) = GN5FLG
             APARAM(3,9,NSUB) = GN6FLG
             APARAM(3,10,NSUB) = GN7FLG
             APARAM(3,1,NSUB) = GAKOVR
             APARAM(3,3,NSUB) = GSTMAX
             APARAM(3,4,NSUB) = GTRATE
             APARAM(3,2,NSUB) = GRFAC
             APARAM(3,5,NSUB) = GIQUAL
  63      CONTINUE
C
C
   65     CONTINUE
C
          GO TO 69
C
C  ASSIGN CARDS LAST SUBAREA -CARD CONSOL. NEGATIVE
C
  66      DO 67 J=I,10
             L = J - 1
             IF (J.LE.8) GO TO 662
             IF (J.EQ.9) GO TO 664
             IF (J.EQ.10) GO TO 665
C
  662        DO 6622 K=1,5
  6622       ALAND(J,K,NSUB) = GAUSE(L,K)
             DO 6624 K=1,7
  6624       AQUAL(J,K,NSUB) = GQC(L,K)
             GO TO 67
C
  664        DO 6642 K=1,5
  6642       ALAND(9,K,NSUB) = GWNAME(K)
             DO 6644 K=1,6
  6644       ALAND(10,K,NSUB) = GAREA(K)
             GO TO 67
C
  665        APARAM(3,6,NSUB) = GN1FLG
             APARAM(3,7,NSUB) = GN5FLG
             APARAM(3,9,NSUB) = GN6FLG
             APARAM(3,10,NSUB) = GN7FLG
```

```
            APARAM(3,1,NSUB) = GAKOVR                                   MAIN 301
            APARAM(3,3,NSUB) = GSTMAX                                   MAIN 302
            APARAM(3,4,NSUB) = GTRATE                                   MAIN 303
            APARAM(3,2,NSUB) = GRFAC                                    MAIN 304
            APARAM(3,5,NSUB) = GIQUAL                                   MAIN 305
 67      CONTINUE                                                       MAIN 306
C                                                                       MAIN 307
C  BYPASS CONVENTIONAL READ AND ASSIGNMENT STATEMENTS.(NCRD=1)          MAIN 308
C                                                                       MAIN 309
 69      GO TO 74                                                       MAIN 310
C                                                                       MAIN 311
C             READ WATERSHED NAME                                       MAIN 312
C                                                                       MAIN 313
  70     READ(READNO,700) (ALAND(1,J,NSUB),J=1,5)                       MAIN 314
 700     FORMAT(2X,5A4)                                                 MAIN 315
C                                                                       MAIN 316
C             READ LAND USE; RUNOFF COEFFICIENT; BOD, SS, VSS, TOTAL N, MAIN 317
C             TOTAL P, AND OTHER CONCENTRATIONS IN MG/L, FOR EACH OF    MAIN 318
C             6 LAND USES.                                              MAIN 319
C                                                                       MAIN 320
         DO 72  I=2,8                                                   MAIN 321
            READ(READNO,720)  (ALAND(I,K,NSUB),K=1,5),(AQUAL(I,K,NSUB), MAIN 322
     *           K=1,7)                                                 MAIN 323
  720       FORMAT(2X,5A4,2X,7F8.2)                                     MAIN 324
 72      CONTINUE                                                       MAIN 325
C                                                                       MAIN 326
C             READ WATERSHED (ALT.) NAME, 6 LAND USE AREAS (IN ACRES)   MAIN 327
C                                                                       MAIN 328
         READ(READNO,720)  (ALAND(9,I,NSUB),I=1,5),(ALAND(10,I,NSUB),   MAIN 329
     *                    I=1,6)                                        MAIN 330
C                                                                       MAIN 331
C             READ:   I/O CONTROLS, GROSS RUNOFF COEFFICIENT (OVERRIDE),MAIN 332
C             MAX STORAGE VOLUME IN MG., TREATMENT WITHDRAWL RATE IN MGDMAIN 333
C             RAINFALL MULTIPLIER, AND QUALITY OPTION                   MAIN 334
C                                                                       MAIN 335
            READ (READNO,721) APARAM(3,6,NSUB),APARAM(3,7,NSUB),        MAIN 336
     *        APARAM(3,9,NSUB),APARAM(3,10,NSUB),APARAM(3,1,NSUB),      MAIN 337
     *        APARAM(3,3,NSUB),APARAM(3,4,NSUB),APARAM(3,2,NSUB),       MAIN 338
     *        APARAM(3,5,NSUB)                                          MAIN 339
  721    FORMAT(2X,F2.0,6X,3F2.0,8X,4F8.2,F1.0)                         MAIN 340
C                                                                       MAIN 341
C        END OF INITIAL READ STATEMENTS                                 MAIN 342
C                                                                       MAIN 343
C        ASSIGN WASHED,WNAME,AUSE(I), ETC.  TO SUBROUTINE ARRAYS        MAIN 344
C                                                                       MAIN 345
 74      DO 75 I=2,8                                                    MAIN 346
            DO 750 J=8,12                                               MAIN 347
               L = J - 7                                                MAIN 348
               AQUAL(I,J,NSUB) = ALAND(I,L,NSUB)                        MAIN 349
 750        CONTINUE                                                    MAIN 350
 75      CONTINUE                                                       MAIN 351
         DO 76 J=1,5                                                    MAIN 352
            AQUAL(1,J,NSUB) = ALAND(1,J,NSUB)                           MAIN 353
            APARAM(1,J,NSUB) = ALAND(1,J,NSUB)                          MAIN 354
            L = J + 5                                                   MAIN 355
            AQUAL(1,L,NSUB) = ALAND(9,J,NSUB)                           MAIN 356
            APARAM(1,L,NSUB) = ALAND(9,J,NSUB)                          MAIN 357
 76      CONTINUE                                                       MAIN 358
C                                                                       MAIN 359
         DO 762 K=1,NSUBS                                               MAIN 360
```

```
            APARAM(3,8,K) = APARAM(3,8,1)                               MAIN 361
 762     CONTINUE                                                       MAIN 362
C                                                                       MAIN 363
      IF (APARAM(3,7,NSUB) .NE. 0) GO TO 764                            MAIN 364
      N5 = 0                                                            MAIN 365
 764  CONTINUE                                                          MAIN 366
C                                                                       MAIN 367
C        READ RAIN CARDS FOR DATA SETS CONTAINING THEM                  MAIN 368
C                                                                       MAIN 369
         IF (N5 .NE. 0.AND.N5 .NE. READNO) GO TO 80                     MAIN 370
         IF (NIN .NE. 0.AND.NIN .NE. READNO) GO TO 80                   MAIN 371
C                                                                       MAIN 372
  77     READ(READNO,770) YDATA,NCARD                                   MAIN 373
  770    FORMAT(6X,I4,6X,I4)                                            MAIN 374
         IF ( YDATA .EQ. 9999) GO TO 78                                 MAIN 375
         DO 771 I=1,NCARD                                               MAIN 376
         READ(READNO,7710) (IMDATA(L),IDDATA(L),IRAIN(L),L=1,10)        MAIN 377
 7710    FORMAT(10(2I2,I4))                                             MAIN 378
 771     CONTINUE                                                       MAIN 379
         GO TO 77                                                       MAIN 380
  78     CONTINUE                                                       MAIN 381
C                                                                       MAIN 382
 80   CONTINUE                                                          MAIN 383
      WRITE(WRITNO,8888)                                                MAIN 384
 8888 FORMAT(1H ,5(/////),1X,'ENTERING SUBROUTINES')                    MAIN 385
      CALL SPARAM                                                       MAIN 386
      CALL SLAND                                                        MAIN 387
      CALL SQUAL                                                        MAIN 388
C                                                                       MAIN 389
 9000 CONTINUE                                                          MAIN 390
      WRITE(WRITNO,9999)                                                MAIN 391
 9999 FORMAT(1H1,//,5X,'ABAG MAC DATA CHECKING PROGRAM SIMULATION',     MAIN 392
     *       ' ENDED')                                                  MAIN 393
C?????CLOSE INPUT DATA FILE IF REQUIRED                                  MAIN 394
C?????CHANGE FOLLOWING RETURN TO CALL EXIT STATEMENT IF REQUIRED         MAIN 395
      RETURN                                                            MAIN 396
      END                                                               MAIN 397
C-----------------------------------------------------------------------MAIN 398
C-----------------------------------------------------------------------PARAM1
C                                                                       PARAM2
      SUBROUTINE SPARAM                                                 PARAM3
C                                                                       PARAM4
C      THIS SUBROUTINE LISTS GLOBAL AND MISCELLANEOUS VARIABLES         PARAM5
C      TO VERIFY THE INPUT DATA                                         PARAM6
C                                                                       PARAM7
      DIMENSION FREQ(2),FREQS(8),FLAGS(2),QOPTS(5,4)                    PARAM8
C??   CHECK THIRD ARRAY DIMENSION                                       PARAM9
      COMMON /PARAM/ APARAM(3,10,25)                                    PARAM10
      COMMON NSUBS,READNO,W[illegible]TNO                                         PARAM11
      INTEGER*4 IHEADG,ICNT,NSUBS,WRITNO,READNO,F,MSTART,YSTART,IPRINT  PARAM12
      REAL*4 APARAM                                                     PARAM13
      DATA FREQS /' DAI','LY  ','MONT','HLY ',' YEA','RLY ','SUBA',     PARAM14
     *             'REA '/                                              PARAM15
      DATA FLAGS /' ','*'/                                              PARAM16
      DATA QOPTS /'    ','   R','UNOF','F   ','    ',                   PARAM17
     *             '    ','  OV','ERFL','OW  ','    ',                   PARAM18
     *             '    ',' TRE','ATME','NT  ','    ',                   PARAM19
     *             'OVER','FLOW',' + T','REAT','MENT'/                  PARAM20
C                                                                       PARAM21
C*****                                                                  PARAM22
```

```
C     PRELIMINARY INITIALIZATION                                        PARAM23
C                                                                       PARAM24
      IHEADG = 0                                                        PARAM25
      ICNT   = 0                                                        PARAM26
      MSTART = APARAM(2,6,1)                                            PARAM27
      YSTART = APARAM(2,7,1)                                            PARAM28
      IPRINT = APARAM(2,8,1)                                            PARAM29
      NCRD   = APARAM(2,9,1)                                            PARAM30
      IF (IPRINT .EQ. 0) IPRINT = 4                                     PARAM31
C                                                                       PARAM32
      DO 1001 I=1,2                                                     PARAM33
         I2 = I                                                         PARAM34
         IF (IPRINT .EQ. 2) I2 = I + 2                                  PARAM35
         IF (IPRINT .EQ. 3) I2 = I + 4                                  PARAM36
         IF (IPRINT .EQ. 4) I2 = I + 6                                  PARAM37
         FREQ(I) = FREQS(I2)                                            PARAM38
 1001 CONTINUE                                                          PARAM39
C                                                                       PARAM40
C     WRITE OUT GLOBAL PARAMETERS                                       PARAM41
C                                                                       PARAM42
      WRITE(WRITNO,100) (APARAM(2,J,1),J=1,5),NSUBS,MSTART,YSTART,      PARAM43
     *     IPRINT,FREQ,NCRD,READNO,WRITNO                               PARAM44
 100  FORMAT(1H1,/////,T50,'GLOBAL PARAMETERS',/////,T20,62('-'),/,     PARAM45
     *      T20,'CLIENT',T50,                                           PARAM46
     *     ' = ',9X,5A4,///,T20,'NUMBER OF SUBAREAS',T50,' = ',9X,I2,   PARAM47
     *     ///,T20,'STARTING DATE',T50,' = ',9X,I2,'/',I5,///,T20,      PARAM48
     *     'PRINTING OPTION',T50,' = ',9X,I2,4X,2A4,///,T20,'INPUT ',   PARAM49
     *     'CARD CONSOLIDATION',T50,' = ',9X,I2,///,T20,'(CARD READ',   PARAM50
     *   ' UNIT NO.)',T50,' = ',9X,I2,///,T20,'(LINE PRINTER UNIT NO.', PARAM51
     *     ')',T50,' = ',9X,I2,/,T20,62('-'),//)                        PARAM52
C                                                                       PARAM53
C*****                                                                  PARAM54
C     BEGIN LOOPS FOR SUBAREA PARAMETERS                                PARAM55
C                                                                       PARAM56
  20  DO 50 K=1,NSUBS                                                   PARAM57
C        CALCULATE MISCELLANEOUS PARAMETERS                             PARAM58
C                                                                       PARAM59
         IOQUAL = APARAM(3,5,K) + 1                                     PARAM60
C                                                                       PARAM61
C        WRITE HEADING IF APPROPRIATE                                   PARAM62
C                                                                       PARAM63
         IF (IHEADG .NE. 0) GO TO 40                                    PARAM64
         IHEADG = 1                                                     PARAM65
         WRITE (WRITNO,200)                                             PARAM66
  200    FORMAT(1H1,///,1X,'SUMMARY',T50,'SUBAREA PARAMETERS',          PARAM67
     *        ///,1H ,'WATERSHED &',13X,' OVERRIDE  ',5X,'    ',        PARAM68
     *        'RAIN   ',6X,'MAXIMUM',8X,'TREATMENT ',                   PARAM69
     *        11X,'QUALITY  OPTION',/,1H ,'SUBAREA NAME',12X,           PARAM70
     *        'COEFFICIENT',5X,'  FACTOR  ',5X,' STORAGE  ',5X,         PARAM71
     *        '   RATE   ',7X,'NUMBER',14X,'NAME',/,1H ,                PARAM72
     *        T57,' MGAL/D   ',5X,'  MGAL/D  ',/,1H ,                   PARAM73
     *        20('-'),4X,5(12('-'),3X),20('-'),/)                       PARAM74
C                                                                       PARAM75
C        WRITE ENTRY IN TABLE                                           PARAM76
C                                                                       PARAM77
  40     WRITE(WRITNO,400) (APARAM(1,J,K),J=1,5)                        PARAM78
  400    FORMAT(1H ,5A4,4X)                                             PARAM79
C                                                                       PARAM80
         WRITE(WRITNO,401) (APARAM(3,J,K),J=1,5),(QOPTS(M,IOQUAL),M=1,5)PARAM81
  401    FORMAT(1H+,T26,2(F12.2,3X),3(F12.0,3X),5A4)                    PARAM82
```

```
         WRITE(WRITNO,402) (APARAM(1,J,K),J=6,10)                       PARAM83
 402     FORMAT(1H ,5A4,/)                                              PARAM84
C                                                                       PARAM85
C        INCREMENT HEADING COUNTER CONTROL                              PARAM86
C                                                                       PARAM87
         ICNT = ICNT + 1                                                PARAM88
         IF (ICNT .GT. 15) IHEADG = 0                                   PARAM89
 50   CONTINUE                                                          PARAM90
C*****                                                                  PARAM91
C     END OF LOOP                                                       PARAM92
C                                                                       PARAM93
 52   WRITE(WRITNO,520)                                                 PARAM94
 520  FORMAT(/,1H ,20('-'),4X,5(12('-'),3X),20('-'),/)                  PARAM95
C                                                                       PARAM96
      IHEADG = 0                                                        PARAM97
      ICNT   = 0                                                        PARAM98
C                                                                       PARAM99
C*****                                                                  PARAM100
C     BEGIN LOOP FOR SUBAREAS                                           PARAM101
C                                                                       PARAM102
 55   DO 80 K=1,NSUBS                                                   PARAM103
C                                                                       PARAM104
C        WRITE I/O OPTIONS                                              PARAM105
C                                                                       PARAM106
C     WRITE HEADING OF APPROPRIATE                                      PARAM107
C                                                                       PARAM108
      IF (IHEADG .NE. 0) GO TO 60                                       PARAM109
      IHEADG = 1                                                        PARAM110
C                                                                       PARAM111
         WRITE(WRITNO,550)                                              PARAM112
 550     FORMAT(1H1,///,T45,'INPUT / OUTPUT OPTIONS',/,                 PARAM113
     *         T58,///,1H ,'WATERSHED &',14X,' LATERAL  ',5X,           PARAM114
     *         'EXISTING  ',5X,'GENERATED ',6X,' TREATED  ',5X,         PARAM115
     *         ' OVERFLOW ',/,1X,'SUBAREA NAME',12X,                    PARAM116
     *         'INFLOW FILE',5X,'RAIN FILE ',5X,'RAIN FILE ',5X,        PARAM117
     *         2('OUTFLOW FILE',3X),/,1H ,20('-'),4X,                   PARAM118
     *         3(12('-'),3X),1X,2(12('-'),3X))                          PARAM119
C                                                                       PARAM120
C     WRITE ENTRY IN TABLE                                              PARAM121
C                                                                       PARAM122
 60      F = 1                                                          PARAM123
         IF (APARAM(3,7,K).GT.0.AND.APARAM(3,8,K).GT.0)                 PARAM124
     *      F = 2                                                       PARAM125
         FLAG = FLAGS(F)                                                PARAM126
C                                                                       PARAM127
         WRITE(WRITNO,400) (APARAM(1,J,K),J=1,5)                        PARAM128
         WRITE(WRITNO,551) (APARAM(3,J,K),J=6,8),FLAG,                  PARAM129
     *        (APARAM(3,J,K),J=9,10)                                    PARAM130
 551     FORMAT(1H+,T26,3(F12.0,3X),A1,3(F12.0,3X))                     PARAM131
         WRITE(WRITNO,402) (APARAM(1,J,K),J=6,10)                       PARAM132
C                                                                       PARAM133
C        INCREMENT HEADING COUNTER CONTROL                              PARAM134
C                                                                       PARAM135
         ICNT  = ICNT + 1                                               PARAM136
         IF (ICNT .GT. 15) IHEADG = 0                                   PARAM137
C                                                                       PARAM138
 80   CONTINUE                                                          PARAM139
C                                                                       PARAM140
C*****                                                                  PARAM141
C     END OF LOOP                                                       PARAM142
```

```
C                                                                       PARAM143
      WRITE(WRITNO,800)                                                 PARAM144
  800 FORMAT(1H ,20('-'),4X,3(12('-'),3X),1X,2(12('-'),3X))             PARAM145
C                                                                       PARAM146
      IF (F .EQ. 1) GO TO 90                                            PARAM147
      WRITE(WRITNO,801)                                                 PARAM148
  801 FORMAT(/,1H ,5X,3H'*',5X,'INDICATES BOTH EXISTING RAINFALL ',     PARAM149
     *      'AND GENERATED RAINFALL FILE OPTIONS HAVE ',                PARAM150
     *      'BEEN CHOSEN ',/,1H ,11X,'ONLY ONE FILE SHOULD BE ',        PARAM151
     *      'ASSIGNED.',//)                                             PARAM152
C                                                                       PARAM153
   90 RETURN                                                            PARAM154
      END                                                               PARAM155
C                                                                       PARAM156
C-----------------------------------------------------------------------PARAM157
C-----------------------------------------------------------------------LAND 1
C                                                                       LAND 2
      SUBROUTINE SLAND                                                  LAND 3
C                                                                       LAND 4
C     THIS SUBROUTINE LISTS LANDUSE NAMES AND AREAS TO VERIFY           LAND 5
C     THE INPUT DATA                                                    LAND 6
C                                                                       LAND 7
C??   CHECK THIRD ARRAY DIMENSION                                       LAND 8
      COMMON /LAND/ ALAND(10,7,25)                                      LAND 9
      COMMON  NSUBS,READNO,WRITNO                                       LAND 10
      INTEGER*4 IHEADG,ICNT,NSUBS,WRITNO,READNO                         LAND 11
      REAL*4 ALAND,TAREA(6),TSARE,SARE                                  LAND 12
C*****                                                                  LAND 13
C     PRELIMINARY INITIALIZATION                                        LAND 14
C                                                                       LAND 15
      IHEADG = 0                                                        LAND 16
      ICNT   = 0                                                        LAND 17
      TSARE  = 0                                                        LAND 18
C                                                                       LAND 19
      DO 2 I=1,6                                                        LAND 20
         TAREA(I) = 0.0                                                 LAND 21
    2 CONTINUE                                                          LAND 22
C                                                                       LAND 23
C*****                                                                  LAND 24
C     BEGIN LOOP FOR EACH SUBAREA                                       LAND 25
C                                                                       LAND 26
   10 DO 80   K=1,NSUBS                                                 LAND 27
C     CALCULATE TOTAL SUBAREA ACREAGE SARE                              LAND 28
C                                                                       LAND 29
         SARE = 0                                                       LAND 30
         DO 40 J=1,6                                                    LAND 31
            SARE = SARE + ALAND(10,J,K)                                 LAND 32
   40    CONTINUE                                                       LAND 33
         TSARE = TSARE + SARE                                           LAND 34
C                                                                       LAND 35
C     WRITE HEADING IF APPROPRIATE                                      LAND 36
C                                                                       LAND 37
         IF (IHEADG .NE. 0) GO TO 50                                    LAND 38
         IHEADG = 1                                                     LAND 39
            WRITE(WRITNO,400)                                           LAND 40
  400       FORMAT(1H1,///,1X,'SUMMARY',T60,'LAND USE ACREAGE',/,T59,   LAND 41
     *             5('-'),'  ACRES ',5('-'),///,1H ,                    LAND 42
     *             'WATERSHED &',14X,'LAND USE 1',5X,'LAND USE 2',5X,   LAND 43
     *             'LAND USE 3',5X,'LAND USE 4',5X,'LAND USE 5',5X,     LAND 44
     *             'LAND USE 6',6X,'TOTAL',/,1H ,'SUBAREA NAME',        LAND 45
```

```
         *              104X,'ACRES',/,1H ,20('-'),4X,6(12('-'),3X),1X,      LAND 46
         *              8('-'))                                               LAND 47
C                                                                             LAND 48
C           WRITE ENTRY IN TABLE                                              LAND 49
C                                                                             LAND 50
  50        WRITE(WRITNO,500) (ALAND(1,J,K),J=1,5)                            LAND 51
  500       FORMAT(1H ,5A4,4X)                                                LAND 52
C                                                                             LAND 53
            WRITE(WRITNO,600) (ALAND(L+1,1,K),ALAND(10,L,K),L=1,6)            LAND 54
  600          FORMAT(1H+,T26,6(1A4,F8.0,3X))                                 LAND 55
            WRITE(WRITNO,601) SARE,(ALAND(9,J,K),J=1,5)                       LAND 56
  601       FORMAT(1H+,T117,F8.0,/,1X,5A4,/)                                  LAND 57
C                                                                             LAND 58
C        INCREMENT HEADING COUNTER COUNTROL                                   LAND 59
C                                                                             LAND 60
            ICNT  = ICNT + 1                                                  LAND 61
            IF (ICNT .GT. 15) IHEADG = 0                                      LAND 62
  80     CONTINUE                                                             LAND 63
C                                                                             LAND 64
C*****                                                                        LAND 65
C        END OF LOOP                                                          LAND 66
C                                                                             LAND 67
         DO 90 J=1,6                                                          LAND 68
            DO 900 K=1,NSUBS                                                  LAND 69
               TAREA(J) = TAREA(J) + ALAND(10,J,K)                            LAND 70
  900       CONTINUE                                                          LAND 71
  90     CONTINUE                                                             LAND 72
C                                                                             LAND 73
C        WRITE FINAL LINE OF TABLE - TOTAL ACREAGE FOR ALL SUBAREAS           LAND 74
C                                                                             LAND 75
  91     WRITE(WRITNO,910) (TAREA(J),J=1,6),TSARE                             LAND 76
  910    FORMAT(1H ,20('-'),4X,6(12('-'),3X),1X,8('-'),/,                     LAND 77
     *         6X,'TOTAL AREA',9X,6(F12.0,3X),1X,F8.0,//)                     LAND 78
         RETURN                                                               LAND 79
         END                                                                  LAND 80
C                                                                             LAND 81
C-----------------------------------------------------------------------------LAND 82
C-----------------------------------------------------------------------------QUAL 1
C                                                                             QUAL 2
         SUBROUTINE SQUAL                                                     QUAL 3
C                                                                             QUAL 4
C        THIS SUBROUTINE LISTS SURFACE RUNOFF POLLUTANT CONCENTRATIONS        QUAL 5
C        TO VERIFY INPUT DATA                                                 QUAL 6
C                                                                             QUAL 7
         DIMENSION QCAVG(6),QCMIN(6),QCMAX(6),PTITLE(12),CTITLE(42)           QUAL 8
         DIMENSION SUBCNT(6)                                                  QUAL 9
C??      CHECK THIRD ARRAY DIMENSION                                          QUAL 10
         COMMON /QUAL/ AQUAL(8,12,25)                                         QUAL 11
         COMMON  NSUBS,READNO,WRITNO                                          QUAL 12
         INTEGER*4 IHEADG,ICNT,NSUBS,WRITNO,READNO,SUBCNT                     QUAL 13
         REAL*4 AQUAL,QCAVG,QCMIN,QCMAX                                       QUAL 14
         DATA PTITLE/'   B','OD  ','   S','S   ','   V','SS  ',               QUAL 15
     *               '  TO','T N ','  TO','T P ','  OT','HER '/               QUAL 16
         DATA CTITLE/'  BI','OCHE','MICA','L OX','YGEN',' DEM','AND ',        QUAL 17
     *               '    ','  SU','SPEN','DED ','SOLI','DS  ','    ',        QUAL 18
     *               '  VO','LATI','LE S','USPE','NDED',' SOL','IDS ',        QUAL 19
     *               '    ','   T','OTAL',' NIT','ROGE','N   ','    ',        QUAL 20
     *               '    ',' TOT','AL P','HOSP','HORO','US  ','    ',        QUAL 21
     *               '    ','    ','   O','THER','    ','    ','    '/        QUAL 22
C                                                                             QUAL 23
```

```
C*****                                                                  QUAL  24
C     PRELIMINARY INITIALIZATION                                        QUAL  25
C                                                                       QUAL  26
      ICNT = 0                                                          QUAL  27
      N = 0                                                             QUAL  28
      I1 = 0                                                            QUAL  29
      I2 = 0                                                            QUAL  30
C                                                                       QUAL  31
C*****                                                                  QUAL  32
C     BEGIN LOOP FOR EACH QUALITY PARAMETER                             QUAL  33
C                                                                       QUAL  34
   20 DO 60 J=2,7                                                       QUAL  35
C                                                                       QUAL  36
C     WRITE SURFACE RUNOFF POLLUTANT CONCENTRATIONS                     QUAL  37
C                                                                       QUAL  38
C        PRELIMINARY INITIALIZATION                                     QUAL  39
C                                                                       QUAL  40
         N = J - 2                                                      QUAL  41
         I1 = J + (6*N) - 1                                             QUAL  42
         I2 = I1 + 6                                                    QUAL  43
         IHEADG = 0                                                     QUAL  44
         ICNT   = 0                                                     QUAL  45
         DO 25 I=1,6                                                    QUAL  46
            QCAVG(I) = 0                                                QUAL  47
            QCMIN(I) = 10000                                            QUAL  48
            QCMAX(I) = 0                                                QUAL  49
            SUBCNT(I) = NSUBS                                           QUAL  50
   25    CONTINUE                                                       QUAL  51
C                                                                       QUAL  52
C        WRITE HEADING IF APPROPRIATE                                   QUAL  53
C                                                                       QUAL  54
   30    DO 50 K=1,NSUBS                                                QUAL  55
            IF (IHEADG .NE. 0) GO TO 40                                 QUAL  56
            WRITE(WRITNO,300) (CTITLE(N),N=I1,I2)                       QUAL  57
  300       FORMAT(1H1,///,1X,'SUMMARY',T38,'SURFACE RUNOFF POLLUTANT', QUAL  58
     *               ' CONCENTRATION',T85,7A4,/,T48,5('-'),'  MG/L  ',  QUAL  59
     *               5('-'),//)                                         QUAL  60
            WRITE(WRITNO,301)                                           QUAL  61
  301       FORMAT(1H ,'WATERSHED &',14X,'LAND USE 1',5X,'LAND USE 2',  QUAL  62
     *             5X,'LAND USE 3',5X,'LAND USE 4',5X,'LAND USE 5',5X,  QUAL  63
     *                 'LAND USE 6',/,1H ,'SUBAREA NAME',/,1H ,20('-'), QUAL  64
     *             4X,6(12('-'),3X))                                    QUAL  65
            IHEADG = 1                                                  QUAL  66
            ICNT = 0                                                    QUAL  67
C                                                                       QUAL  68
C           WRITE ENTRY IN TABLE                                        QUAL  69
C                                                                       QUAL  70
   40       WRITE(WRITNO,400) (AQUAL(1,L,K),L=1,5)                      QUAL  71
  400       FORMAT(1H ,5A4,4X)                                          QUAL  72
C                                                                       QUAL  73
               WRITE(WRITNO,420) (AQUAL(I,8,K),AQUAL(I,J,K),I=2,7)      QUAL  74
  420          FORMAT(1H+,T26,6(1A4,F8.2,3X))                           QUAL  75
            WRITE(WRITNO,421) (AQUAL(1,L,K),L=6,10)                     QUAL  76
  421       FORMAT(1H ,5A4,/)                                           QUAL  77
C                                                                       QUAL  78
C                                                                       QUAL  79
C           INCREMENT HEADING FOR COUNTER COUNTROL                      QUAL  80
C                                                                       QUAL  81
            ICNT = ICNT + 1                                             QUAL  82
            IF (ICNT .GT. 15) IHEADG = 0                                QUAL  83
            DO 45 I=2,7                                                 QUAL 84
               N = I - 1                                                QUAL 85
               QCMIN(N) = AMIN1(QCMIN(N),AQUAL(I,J,K))                  QUAL 86
               QCMAX(N) = AMAX1(QCMAX(N),AQUAL(I,J,K))                  QUAL 87
               QCAVG(N) = QCAVG(N) + AQUAL (I,J,K)                      QUAL 88
               IF(AQUAL(I,J,K) .EQ. 0) SUBCNT(N) = SUBCNT(N) - 1        QUAL 89
 45         CONTINUE                                                    QUAL 90
 50      CONTINUE                                                       QUAL 91
         DO 55 I=1,6                                                    QUAL 92
            IF (SUBCNT(I) .EQ. 0) GO TO 53                              QUAL 93
            QCAVG(I) = QCAVG(I) / SUBCNT(I)                             QUAL 94
            GO TO 55                                                    QUAL 95
 53         QCAVG(I) = 0.0                                              QUAL 96
 55      CONTINUE                                                       QUAL 97
         WRITE(WRITNO,550) QCAVG,QCMAX,QCMIN                            QUAL 98
 550     FORMAT(1H ,20('-'),4X,6(12('-'),3X),/,                         QUAL 99
     *           5X,'AVERAGE-NONZERO',5X,6(F12.2,3X),/,                 QUAL 100
     *           5X,'MAXIMUM',13X,6(F12.2,3X),/,                        QUAL 101
     *           5X,'MINIMUM',13X,6(F12.2,3X),////)                     QUAL 102
 60   CONTINUE                                                          QUAL 103
C                                                                       QUAL 104
C*****                                                                  QUAL 105
C     END LOOP                                                          QUAL 106
C                                                                       QUAL 107
C     WRITE GROSS RUNOFF COEFFICIENTS - K                               QUAL 108
C                                                                       QUAL 109
C     PRELIMINARY INITIALIZATION                                        QUAL 110
C                                                                       QUAL 111
      IHEADG = 0                                                        QUAL 112
      ICNT   = 0                                                        QUAL 113
      DO 12 I=1,6                                                       QUAL 114
         QCMAX(I) = 0                                                   QUAL 115
         QCMIN(I) = 10000                                               QUAL 116
 12   CONTINUE                                                          QUAL 117
C                                                                       QUAL 118
C*****                                                                  QUAL 119
C     BEGIN LOOP FOR SUBAREAS                                           QUAL 120
C                                                                       QUAL 121
 13   DO 19 K=1,NSUBS                                                   QUAL 122
C                                                                       QUAL 123
C        WRITE HEADING IF APPROPRIATE                                   QUAL 124
C                                                                       QUAL 125
         IF(IHEADG .NE. 0) GO TO 14                                     QUAL 126
         WRITE(WRITNO,130)                                              QUAL 127
 130     FORMAT(1H1,///,1X,'SUMMARY',T44,'GROSS RUNOFF COEFFICIENT',    QUAL 128
     *      'S - K',//)                                                 QUAL 129
         WRITE(WRITNO,301)                                              QUAL 130
         IHEADG = 1                                                     QUAL 131
         ICNT   = 0                                                     QUAL 132
C                                                                       QUAL 133
C        WRITE ENTRY IN TABLE                                           QUAL 134
C                                                                       QUAL 135
 14      WRITE(WRITNO,400) (AQUAL(1,L,K),L=1,5)                         QUAL 136
         WRITE(WRITNO,420) (AQUAL(I,8,K),AQUAL(I,1,K),I=2,7)            QUAL 137
         WRITE(WRITNO,160) (AQUAL(1,L,K),L=6,10)                        QUAL 138
 160     FORMAT(1H ,5A4,/)                                              QUAL 139
C                                                                       QUAL 140
C        INCREMENT HEADING FOR COUNTER CONTROL                          QUAL 141
C                                                                       QUAL 142
         ICNT = ICNT + 1                                                QUAL 143
         IF ( ICNT .GT. 15 ) IHEADG = 0                                 QUAL 144
         DO 17 I=2,7                                                    QUAL 145
            N = I - 1                                                   QUAL 146
            QCMIN(N) = AMIN1(QCMIN(N),AQUAL(I,1,K))                     QUAL 147
            QCMAX(N) = AMAX1(QCMAX(N),AQUAL(I,1,K))                     QUAL 148
 17      CONTINUE                                                       QUAL 149
 19   CONTINUE                                                          QUAL 150
C                                                                       QUAL 151
C*****                                                                  QUAL 152
C     END LOOP                                                          QUAL 153
C                                                                       QUAL 154
      WRITE(WRITNO,190) QCMAX,QCMIN                                     QUAL 155
 190  FORMAT(1H ,20('-'),4X,6(12('-'),3X),/,                            QUAL 156
     *      5X,'MAXIMUM',13X,6(F12.2,3X),/,                             QUAL 157
     *      5X,'MINIMUM',13X,6(F12.2,3X),///)                           QUAL 158
C                                                                       QUAL 159
C     WRITE POLLUTANT CONCENTRATIONS FOR TREATMENT                      QUAL 160
C                                                                       QUAL 161
C          PRELIMINARY INITIALIZATION                                   QUAL 162
C                                                                       QUAL 163
 61   IHEADG = 0                                                        QUAL 164
      ICNT = 0                                                          QUAL 165
      DO 63 J=1,6                                                       QUAL 166
         QCMIN(J) = 10000                                               QUAL 167
         QCMAX(J) = 0.0                                                 QUAL 168
         QCAVG(J) = 0.0                                                 QUAL 169
         SUBCNT(J) = NSUBS                                              QUAL 170
 63   CONTINUE                                                          QUAL 171
C                                                                       QUAL 172
C*****                                                                  QUAL 173
C     BEGIN LOOP FOR SUBAREAS                                           QUAL 174
C                                                                       QUAL 175
      DO 70 K=1,NSUBS                                                   QUAL 176
C        WRITE HEADING IF APPROPRIATE                                   QUAL 177
C                                                                       QUAL 178
         IF (IHEADG .NE. 0) GO TO 74                                    QUAL 179
 65      WRITE(WRITNO,650) (PTITLE(I),I=1,12)                           QUAL 180
 650     FORMAT(1H1,///,1X,'SUMMARY',T40,'TREATED EFFLUENT CONCEN',     QUAL 181
     *             'TRATION',/,T46,5('-'),'  MG/L  ',5('-'),//,         QUAL 182
     *             1X,'WATERSHED &',14X,6(1X,2A4,6X),/,1H ,'SUBAREA ',  QUAL 183
     *             'NAME',/,1H ,20('-'),4X,6(12('-'),3X),/)             QUAL 184
         IHEADG = 1                                                     QUAL 185
C                                                                       QUAL 186
C        WRITE ENTRY IN TABLE                                           QUAL 187
C                                                                       QUAL 188
  74     WRITE(WRITNO,740) (AQUAL(1,L,K),L=1,5),(AQUAL(8,L,K),L=2,7),   QUAL 189
     *            (AQUAL(1,L,K),L=6,10)                                 QUAL 190
  740    FORMAT(1H ,5A4,4X,6(F12.2,3X),/,1X,5A4,/)                      QUAL 191
         ICNT = ICNT + 1                                                QUAL 192
         IF (ICNT .GT. 15) IHEADG = 0                                   QUAL 193
         DO 75 J=2,7                                                    QUAL 194
            L = J - 1                                                   QUAL 195
            QCMIN(L) = AMIN1(QCMIN(L),AQUAL(8,J,K))                     QUAL 196
            QCMAX(L) = AMAX1(QCMAX(L),AQUAL(8,J,K))                     QUAL 197
            QCAVG(L) = QCAVG(L) + AQUAL (8,J,K)                         QUAL 198
            IF (AQUAL(8,J,K) .EQ. 0) SUBCNT(L) = SUBCNT(L) - 1          QUAL 199
  75     CONTINUE                                                       QUAL 200
  70   CONTINUE                                                         QUAL 201
C                                                                       QUAL 202
C*****                                                                  QUAL 203
```

```
C     END LOOP                                                          QUAL 204
C                                                                       QUAL 205
      DO 80 J=1,6                                                       QUAL 206
         IF (SUBCNT(J) .EQ.0) GO TO 83                                  QUAL 207
         QCAVG(J) = QCAVG(J) / SUBCNT(J)                                QUAL 208
         GO TO 80                                                       QUAL 209
 83      QCAVG(J) = 0.0                                                 QUAL 210
 80   CONTINUE                                                          QUAL 211
      WRITE(WRITNO,550) QCAVG,QCMAX,QCMIN                               QUAL 212
C                                                                       QUAL 213
      RETURN                                                            QUAL 214
      END                                                               QUAL 215
C                                                                       QUAL 216
C-----------------------------------------------------------------------QUAL 217
```